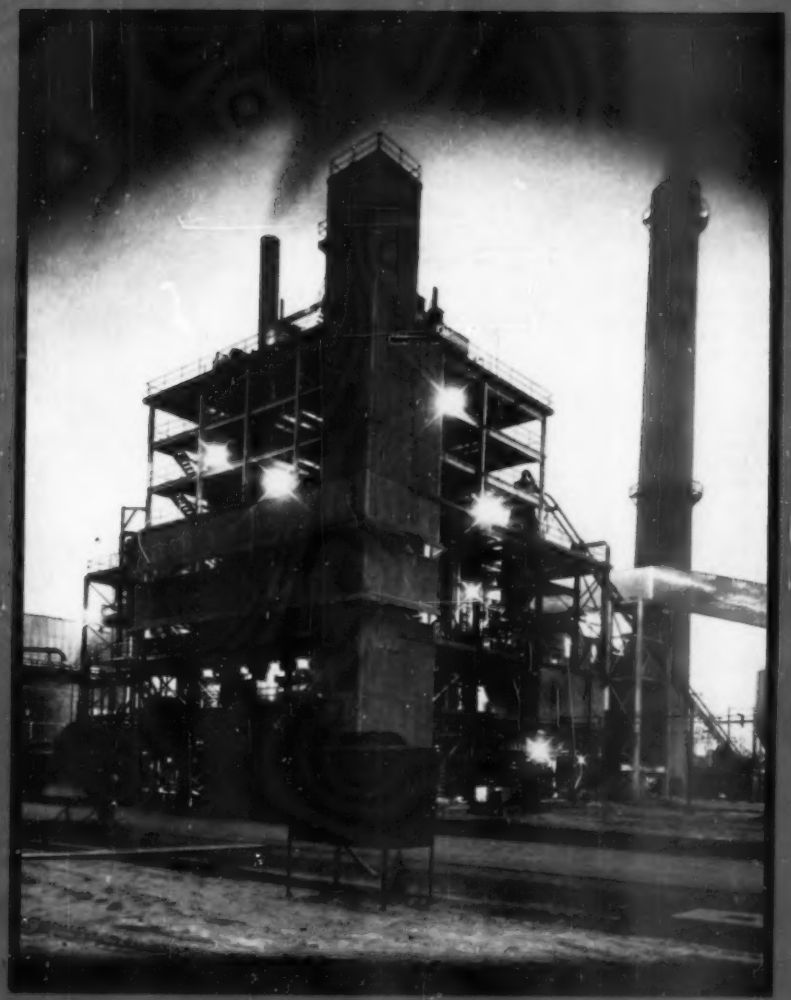
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

June 1957



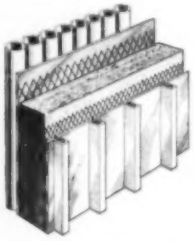
The power plant of the Evadale, Texas installation of the East Texas Pulp and Paper Co.

NEMA Piping Standards for Turbines

Projecting Steam Costs to 1980

Case History of Automatic Ash Handling

Thermal Problems of Automatic Power Stations

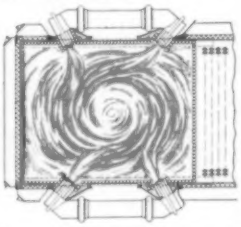


DOUBLE WALL, PRESSURE-TIGHT CASING. The latest development in casing construction for pressure firing of boilers in the size class of the VU-55, this casing is designed to assure life-time tightness with minimum heat loss. Pressure firing permits the elimination of an induced draft fan with its attendant operating and maintenance costs. Construction consists of tangent tubes backed up successively by welded steel panels, 4 inches of high quality insulating material and an outer steel casing formed as shown to provide adequately for expansion and assure ample strength. Low heat loss and the tightness required for pressure firing are assured by this double-wall construction.

HIGH STEAM QUALITY. Equipped with a large (60-in.) steam drum, the VU-55 has generous water capacity and steam reservoir space. C-E drum internals assure high quality steam at all ratings.

TANGENT FURNACE TUBES. The VU-55's furnace tube arrangement provides complete heat-absorbing, water-cooled protection on all furnace walls. Furnace maintenance is minimized, refractory expense is eliminated, heat absorption rates per sq. ft. are higher.

TANGENTIAL FIRING. More than 20 years of application experience have established the exceptional advantages of tangential firing. About 90 per cent of Combustion's large utility installations use this advanced method of firing. Flame streams from the four burners impinge upon one another at high velocity, as shown, creating a turbulence unattainable by any other method of firing. The result is rapid and complete combustion. As the gases spiral upward, they sweep all furnace heating surfaces, assuring a high rate of heat absorption.



STREAMLINED EXTERIOR. The over-all appearance of the VU-55 reflects the efforts of its designers to achieve a completely unobstructed casing, while retaining adequate access wherever required and every facility for convenient operation. There are no outside downcomer tubes, and ducts from the air heater to the burners are located beneath the furnace floor.

The VU-55 Boiler...

Custom Features, Standard Sizes, Advanced Design

The VU-55, newest of the C-E line of Vertical Unit Boilers, represents the closest approach to central station performance yet achieved in standardized boilers in its capacity range.

Its design combines a number of time-tested and service-proved features, such as Tangential Burners, double wall, pressure-tight casing, and tangent furnace tubes. In addition, this bottom-supported unit requires no outside supporting steel, is economical of space and streamlined in appearance.

It is available in 5 sizes for capacities from 50,000 to 120,000 lb per hour. It is designed for 3 pressure ranges (250, 500 and 750 psi) and can be equipped with a superheater to provide temperatures up to 750 F. Either a tubular or a regenerative air heater is available.

The VU-55 Boiler is symmetrical in design, performs efficiently over a wide range of output, and is easy to operate and maintain.

It is, in fact, the boiler with the custom features and the advanced design.

COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

Canada: Combustion Engineering-Superheater Ltd.

B-978A

all types of steam generating, fuel burning and related equipment; nuclear reactors; paper mill equipment; pulverizers; flash drying systems; pressure vessels; soil pipe.

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 28 **No. 12**

June 1957

Feature Articles

NEMA Approves Piping Standards for Industrial Service Turbines 35

Projecting Steam Costs to 1980 ..... *by J. H. Harlow* 41

A Case History of Automatic Ash and Dust Handling Progress ..... *by B. C. Berry* 45

Thermal Problems of Atomic Power Stations—II ..... *by C. E. Lundgren and C. Seippel* 51

Editorials

Graduation Day...Planned and Plotted 34

Departments

New Catalogs and Bulletins 59

Personals 63

Annual Index 71–77

Advertising Index 78–79

COMBUSTION published its annual index in the June issue and is indexed regularly by Engineering Index, Inc.

The magazine is now reproduced and distributed to libraries on microfilm by University Microfilms of Ann Arbor, Michigan.

GERALD S. CARRICK
Business Manager

JOSEPH C. McCABE
Editor

GLENN R. FRYLING
Associate Editor

CARL G. UDELL
Circulation Manager

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING, INC.

Joseph V. Santry, Pres.; Charles McDonough, Vice-Pres.; Otto Strauss, Treas.; Thomas A. Ennis, Secy.
COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $4 in the United States, $5.50 in Canada; and $8 in Latin America and other countries. Single copies: Domestic, 40 cents; Foreign, 60 cents plus postage. Copyright 1957 by Combustion Publishing Company, Inc. Publication Office, Easton, Pa. Issued the middle of the month of publication.
Acceptance under Section 34.64, P.L. & R., authorized by United States Post Office.

BPA

Printed in U. S. A.

WELBOND®

is the valve

for high pressures, high temperatures

Yarway Welbond Valves are available in 9 sizes, ¼" to 2½", angle and straightway designs. Pressures to 2500 psi, temperatures to 1050° F.

Welbond is the valve designed by Yarway specifically to provide modern steam power plants with the ultimate in high pressure, high temperature valve service.

These special Welbond features insure improved valve performance:

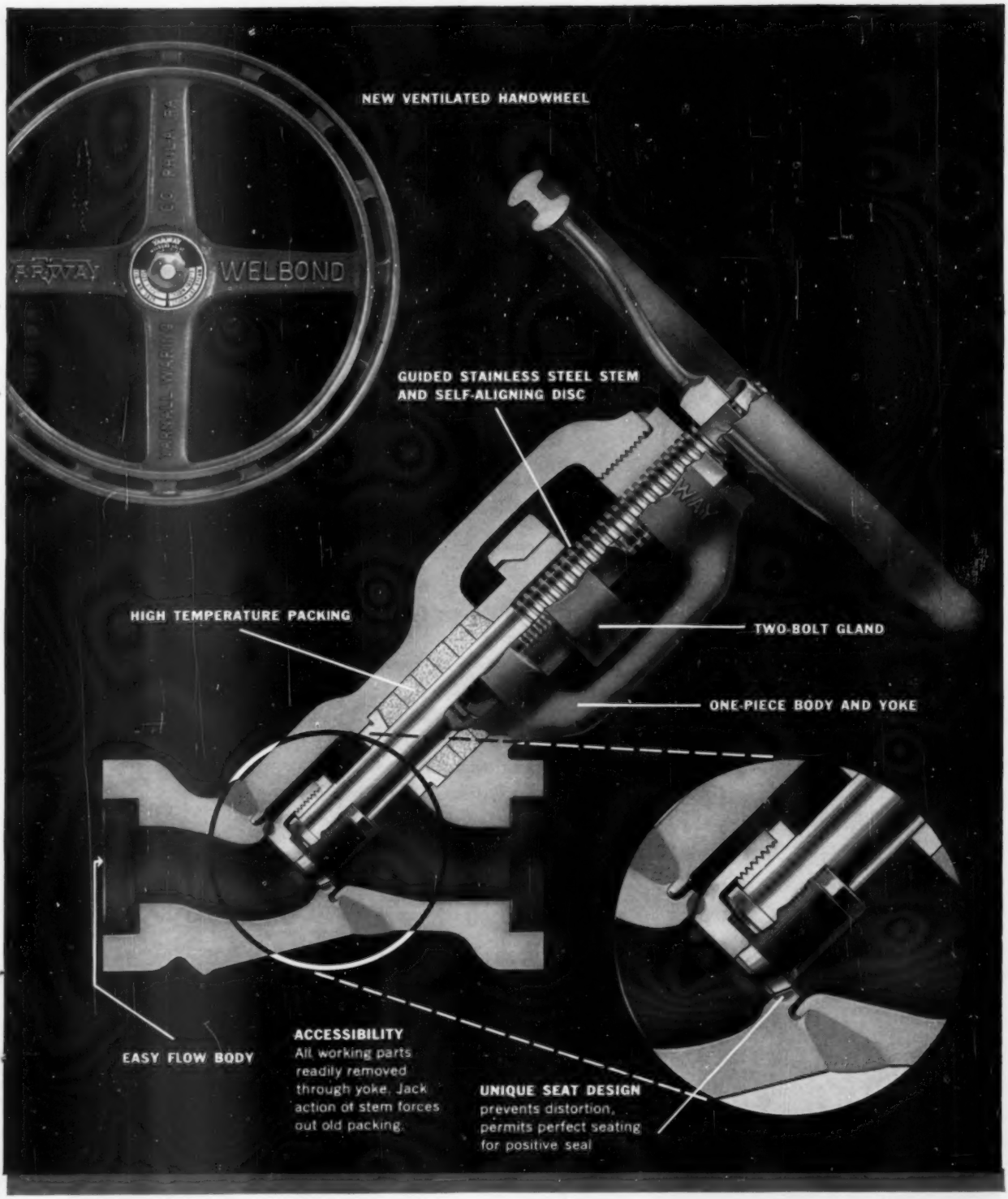
- **Stem** of 321 stainless steel, used with special **packing** to prevent stem corrosion
- Easy and quick **accessibility.** All working parts removable through yoke.
- Non-distorting, thermally-compensated **seat**
- Ventilated, easy grip **handwheel**
- **Streamlined flow** through body

Welbond Valves are winning approval on superheater vents and drains, water wall drains, economizer drains, steam gage shut-off, strainer blow-off and many other steam plant services. Your Yarway man will be glad to discuss applications for your plant.

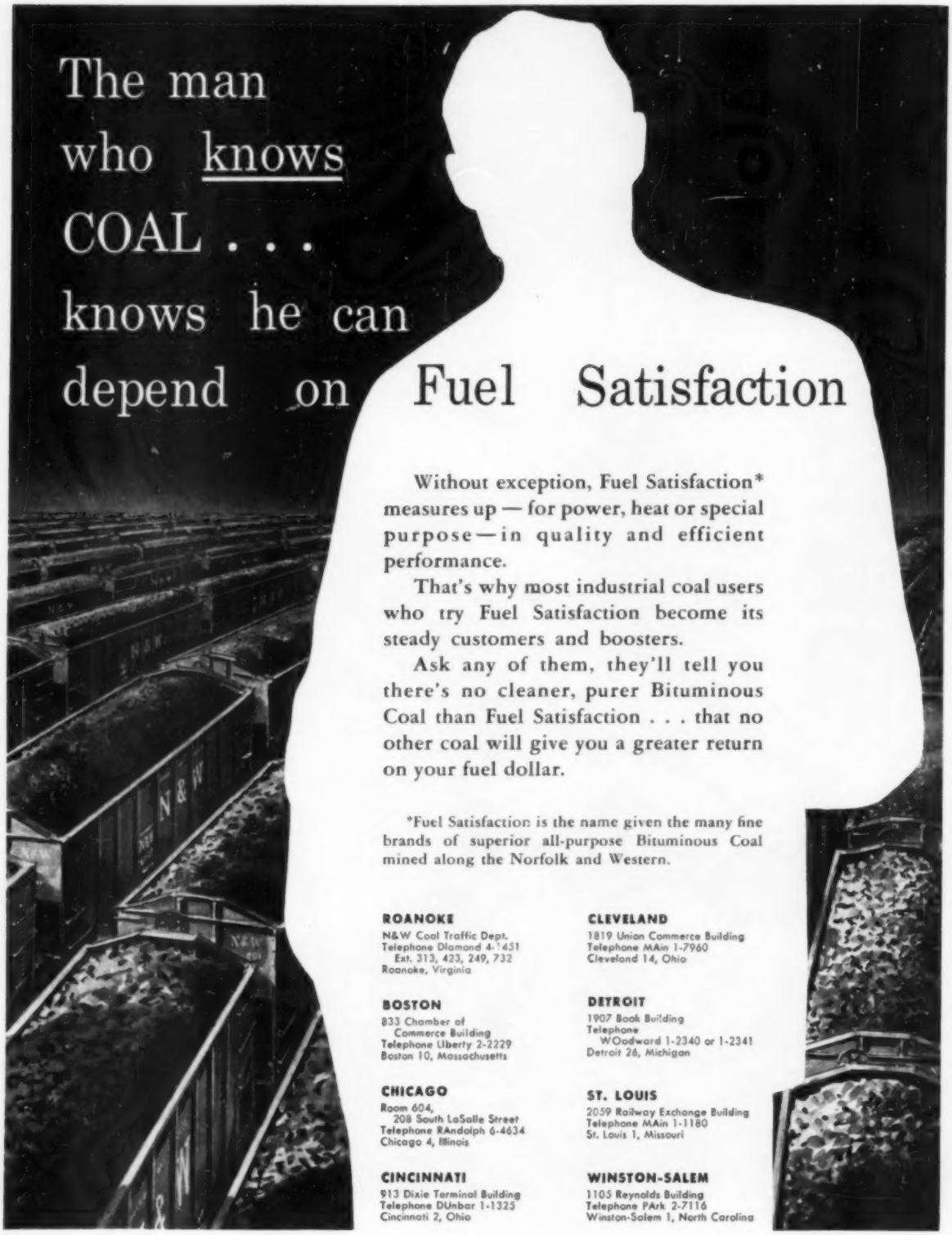
For full information, write for Yarway Bulletin B-452.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY WELBOND . . . a good


NEW VENTILATED HANDWHEEL
WELBOND
GUIDED STAINLESS STEEL STEM
AND SELF-ALIGNING DISC
HIGH TEMPERATURE PACKING
TWO-BOLT GLAND
ONE-PIECE BODY AND YOKE
EASY FLOW BODY
ACCESSIBILITY
All working parts readily removed through yoke. Jack action of stem forces out old packing.
UNIQUE SEAT DESIGN
prevents distortion, permits perfect seating for positive seal

way to specify high pressure/high temperature valves



Without exception, Fuel Satisfaction* measures up — for power, heat or special purpose — in quality and efficient performance.

That's why most industrial coal users who try Fuel Satisfaction become its steady customers and boosters.

Ask any of them, they'll tell you there's no cleaner, purer Bituminous Coal than Fuel Satisfaction . . . that no other coal will give you a greater return on your fuel dollar.

*Fuel Satisfaction is the name given the many fine brands of superior all-purpose Bituminous Coal mined along the Norfolk and Western.

ROANOKE
N&W Coal Traffic Dept.
Telephone Diamond 4-1451
Ext. 313, 423, 249, 732
Roanoke, Virginia

BOSTON
833 Chamber of Commerce Building
Telephone Liberty 2-2229
Boston 10, Massachusetts

CHICAGO
Room 604,
208 South LaSalle Street
Telephone RAndolph 6-4634
Chicago 4, Illinois

CINCINNATI
913 Dixie Terminal Building
Telephone DUnbar 1-1325
Cincinnati 2, Ohio

CLEVELAND
1819 Union Commerce Building
Telephone MAin 1-7960
Cleveland 14, Ohio

DETROIT
1907 Book Building
Telephone
WOodward 1-2340 or 1-2341
Detroit 26, Michigan

ST. LOUIS
2059 Railway Exchange Building
Telephone MAin 1-1180
St. Louis 1, Missouri

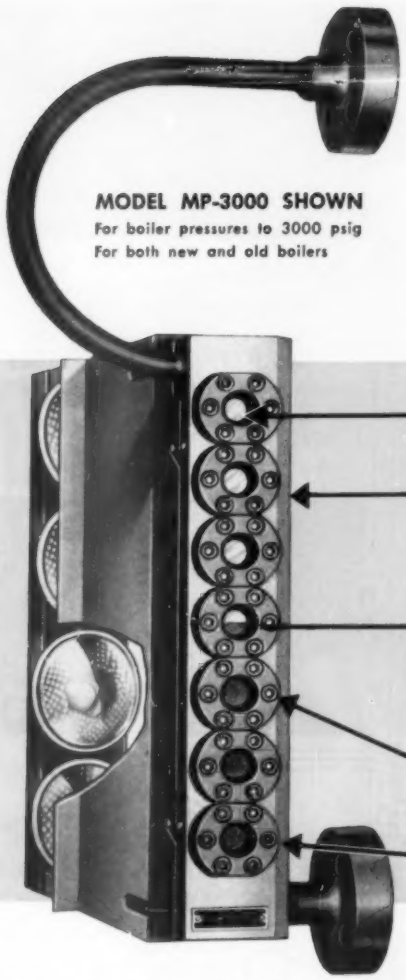
WINSTON-SALEM
1105 Reynolds Building
Telephone PArk 2-7116
Winston-Salem 1, North Carolina

Norfolk and Western Railway

CARRIER OF FUEL SATISFACTION

MORE THAN ~~950~~ 1400 DIAMOND MULTI-PORT GAUGES

In use and on order for over ~~240~~ 300 Central Station Generating Plants



MODEL MP-3000 SHOWN
For boiler pressures to 3000 psig
For both new and old boilers

- SMALL ROUND PORTS INSTEAD OF LONG GLASS AND MICA STRIPS
- GAUGE NEVER REMOVED FROM BOILER FOR GASKET CHANGES OR OTHER NORMAL MAINTENANCE
- STEAM SHOWS RED
- WATER SHOWS GREEN
- COMPLETE PORT CHANGE REQUIRES ONLY ABOUT 15 MINUTES
- EACH PORT THERMALLY INDEPENDENT

Also available is Model MP-900 for boiler pressures to 900 psig

Because the Diamond Multi-Port solves the problems inherent in water level gauges on boilers operating at high temperatures and pressures, it has had rapid and wide acceptance. In addition to the 1400 for central station generating plants, more than 150 have been sold to industrial power plants.

Advantages of the Multi-Port are many. In addition to those shown above, it has maximum thermal stability for rapid starting . . . "Hi-Lite" illuminator for improved readability . . . welded construction for permanent tightness . . . end stems can be furnished instead of flanges . . . startling reductions in maintenance costs.

Write for Bulletin 1174 (Model MP-3000) or Bulletin 2044 (Model MP-900) for more information.

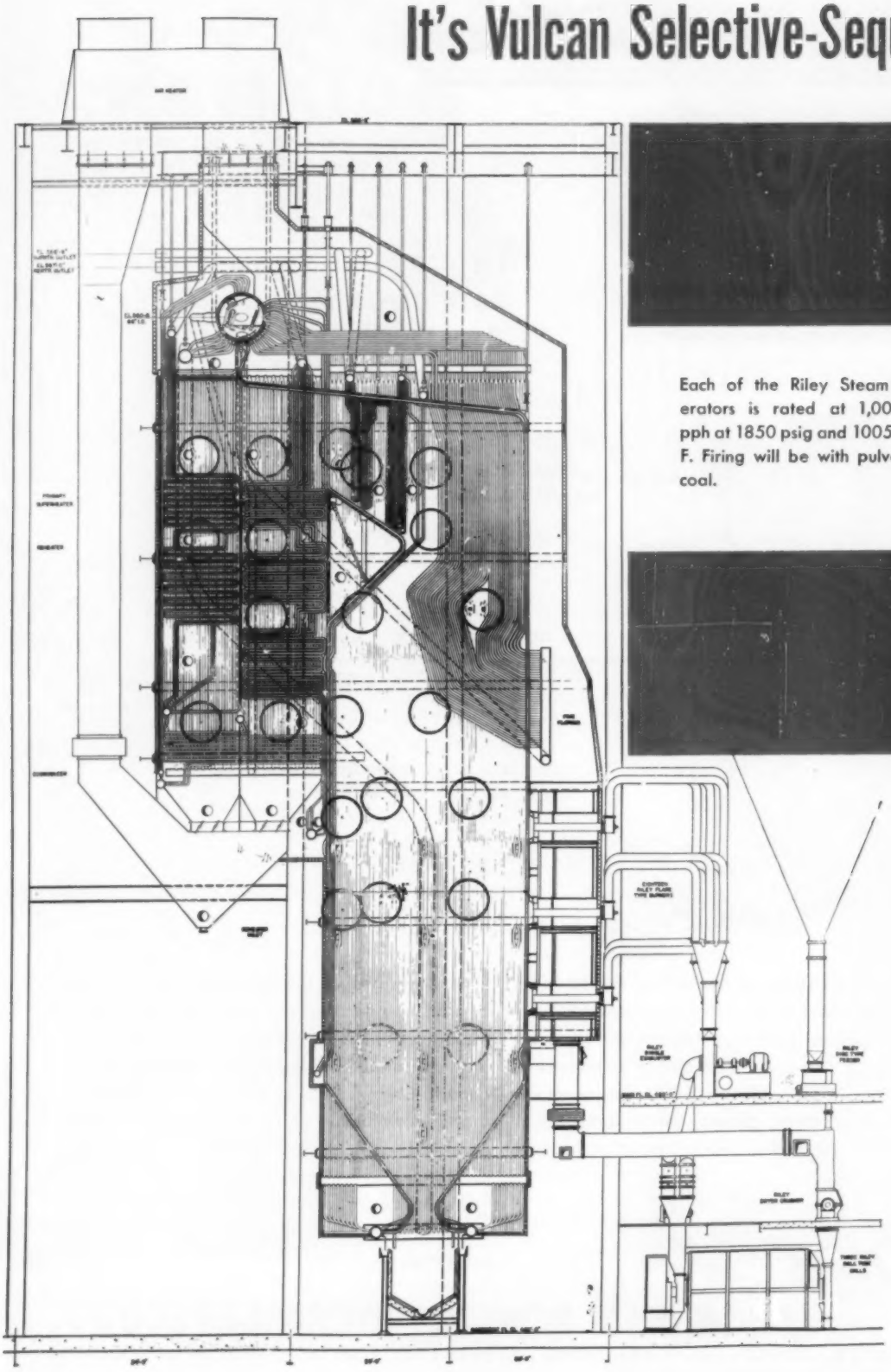
7801

Diamond

DIAMOND POWER SPECIALTY CORP.

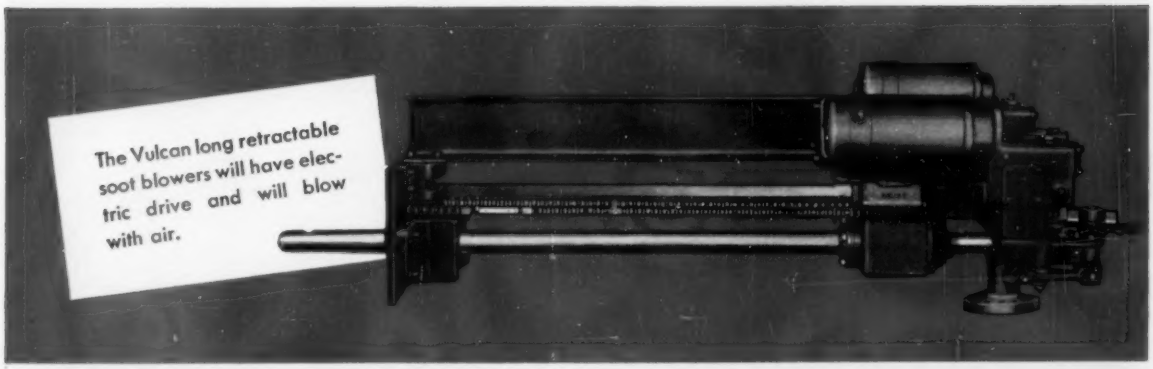
LANCASTER, OHIO • DIAMOND SPECIALTY LIMITED — *Windsor, Ontario*

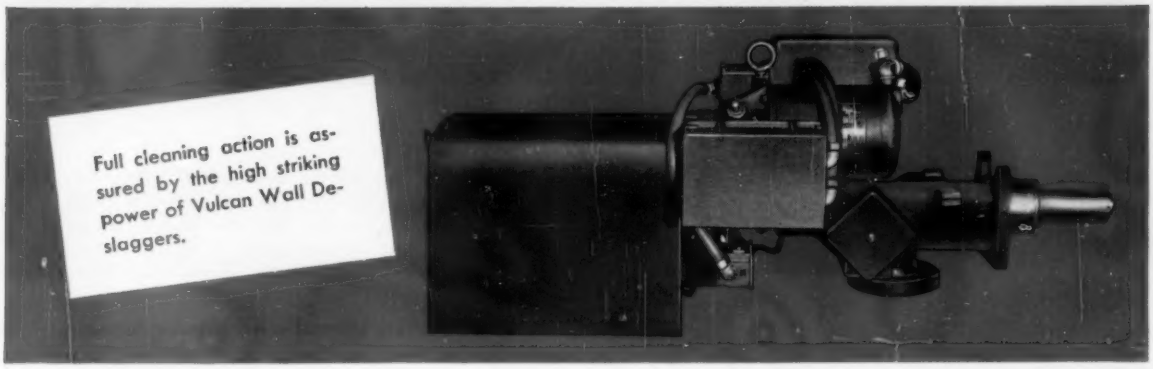
It's Vulcan Selective-Sequence



Each of the Riley Steam Generators is rated at 1,000,000 pph at 1850 psig and 1005/1005 F. Firing will be with pulverized coal.

at New Albany Generating Station





Boiler cleaning systems for Units 1 and 2 in the New Albany Station of Public Service Company of Indiana will be under Vulcan Selective-Sequence Control. Each of the two Riley Steam Generators will be equipped with a Vulcan Soot Blowing System which includes Long Retracts and Wall Deslaggers.

Selective-Sequence operation of the soot blowing system was chosen to give positive operation at proper intervals in precisely the sequence necessary for the most effective cleaning. Vulcan Long Retractable Soot Blowers with two motor operation assure maximum coverage with uniform cleaning of all surfaces. Vulcan Wall Deslaggers deliver maximum striking power to drive off slag, assuring high heat-transfer capacity and uniform control of superheat and reheat temperatures.

Modern soot blowing systems, with either automatic-sequential or selective-sequence control, can help keep your boilers operating at peak efficiency. Whether your boiler is power or process, large or small, investigate Vulcan Automatic Soot Blowing Systems for better cleaning results.

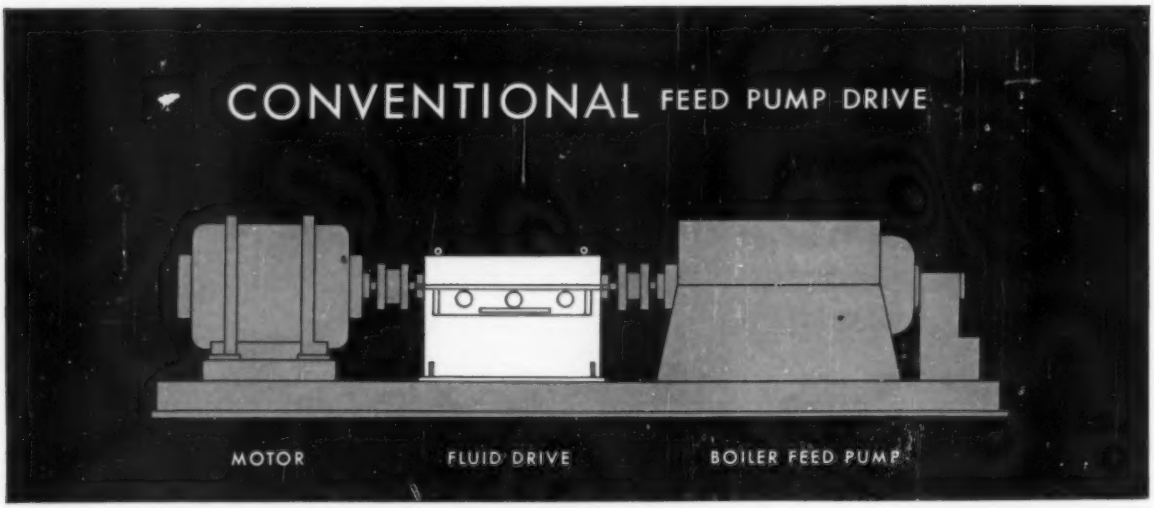
COPES-VULCAN DIVISION

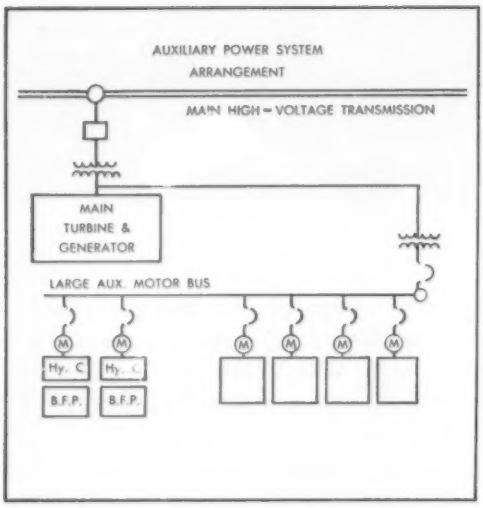
BLAW-KNOX COMPANY

ERIE 4, PENNSYLVANIA

50th Anniversary BLAW-KNOX 1906-1956

How *Gýrol*® Fluid Drive meets all

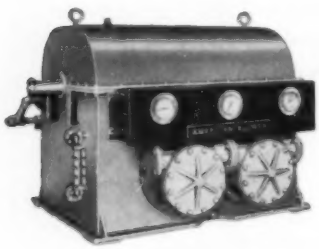




Of all power-plant auxiliaries, the boiler feed pump consumes the greatest single segment of invested power. To release more of this power to consumer lines, power plants of all sizes are controlling feed water flow by speed regulation through Gýrol Fluid Drive—driven by a constant speed prime mover.

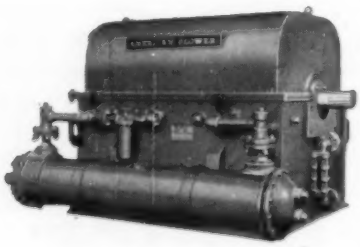
Gýrol Fluid Drive offers several specific advantages:

1. It saves power over the entire operating range by eliminating wasteful throttling by valves.
2. Fluid Drive's adjustable-speed feature permits reduction in pressure—resulting in further power savings.
3. It reduces wear on bearings, and other vital pump parts, by letting the pump operate at speeds that fit boiler demands.
4. With Fluid Drive, paralleling of pumps is simplified. Change-over from operating to standby pump is quick and easy.
5. Quiet operation is inherent in the design of Fluid Drive, since a "cushion of oil" is the means of energy transmission.



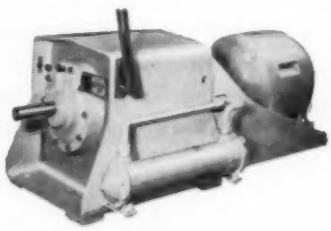
TYPE VS CLASS 6

- adjustable speed control
- 250 to 12,000 horsepower
- speeds to 3600 rpm



TYPE VS CLASS 4

- adjustable speed control
- 100 to 2500 horsepower
- speeds to 1800 rpm

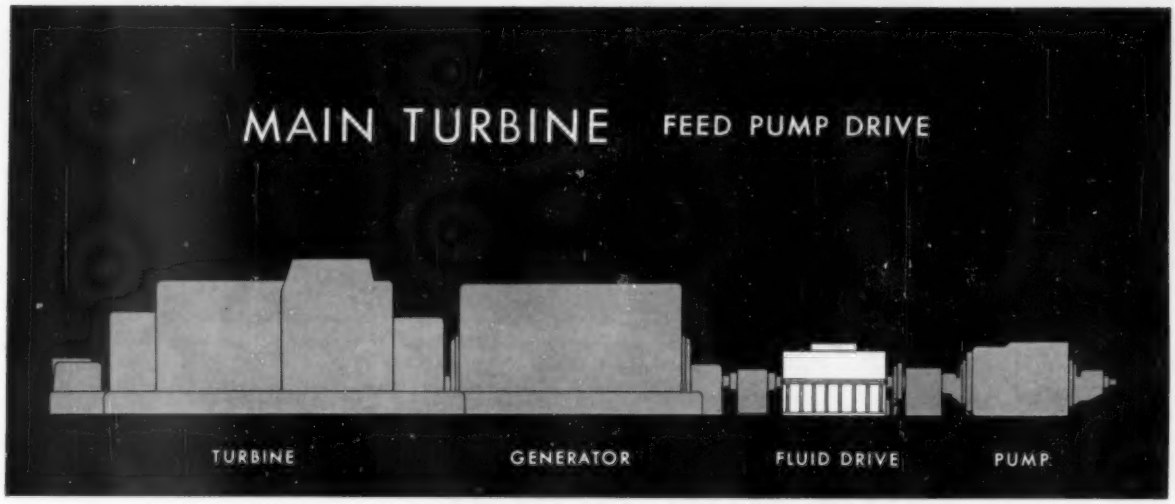


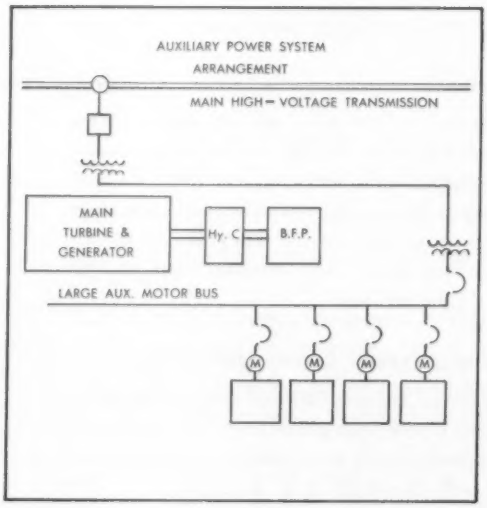
TYPE VS CLASS 2

- adjustable speed control
- 1 to 800 horsepower
- speeds to 1800 rpm

requirements for feed pump control

Regardless of station size, arrangement, or prime mover, you get the advantages of power savings, reduced pressures, and quiet operation with American Blower Gýrol Fluid Drives





Already in the construction stage is the use of Gýrol Fluid Drive for main turbine feed pump drives on some of the largest generating units yet projected.

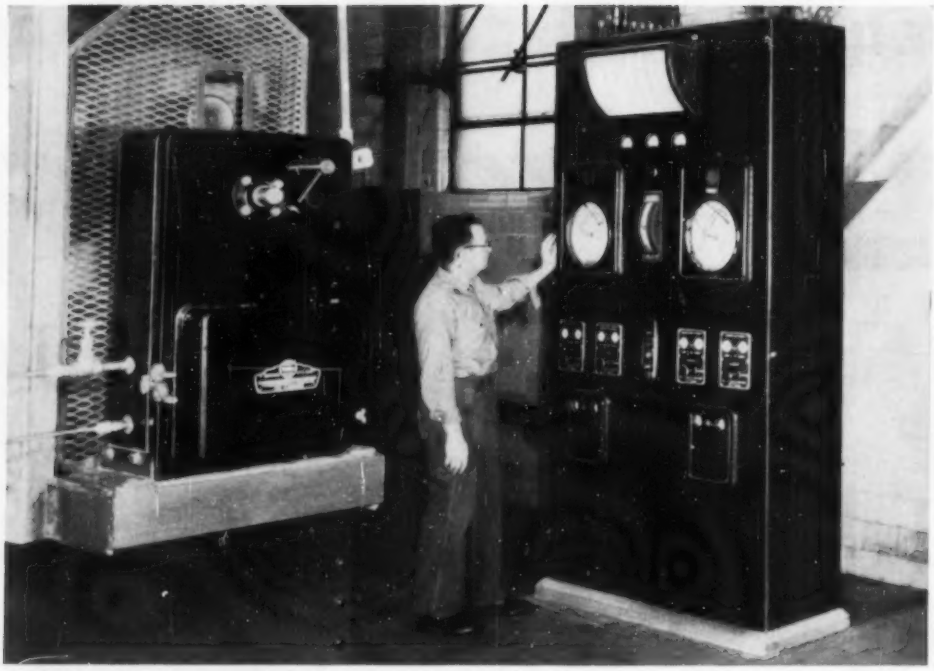
For example, two of these stations will each drive, through a 12,000-hp adjustable-speed Gýrol Fluid Drive, the main feed pump from the high-pressure turbine. Full boiler capacities will be supplied by the single 5-stage pump, each delivering 6330 gpm against 6400 feet total discharge head when operating at 3510 rpm with feed water at 363° F.

Each pump requires an excess of 11,000 hp, and will be driven from the generator shaft through an adjustable-speed Gýrol Fluid Drive.

In your plans for expansion, why not discuss the advantages of Gýrol Fluid Drive with an American Blower engineer. His knowledge of this application in modern power plants may prove valuable to you. Call our nearest branch, or write: American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

AMERICAN BLOWER

Division of AMERICAN-Standard



This Bailey Control System helps cut fuel costs on a 70,000 lb per hr capacity 125 psi boiler in an industrial plant. Control drive in foreground regulates stoker.

How Bailey stretches your fuel dollar...

You can wring more energy out of a dollar's worth of fuel when you are getting optimum performance from your steam plant equipment. You get peak performance when Bailey Meters and Controls are on the job. They increase your plant efficiency.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

1. Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs. Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering control on your steam plant control problems.

A132-1

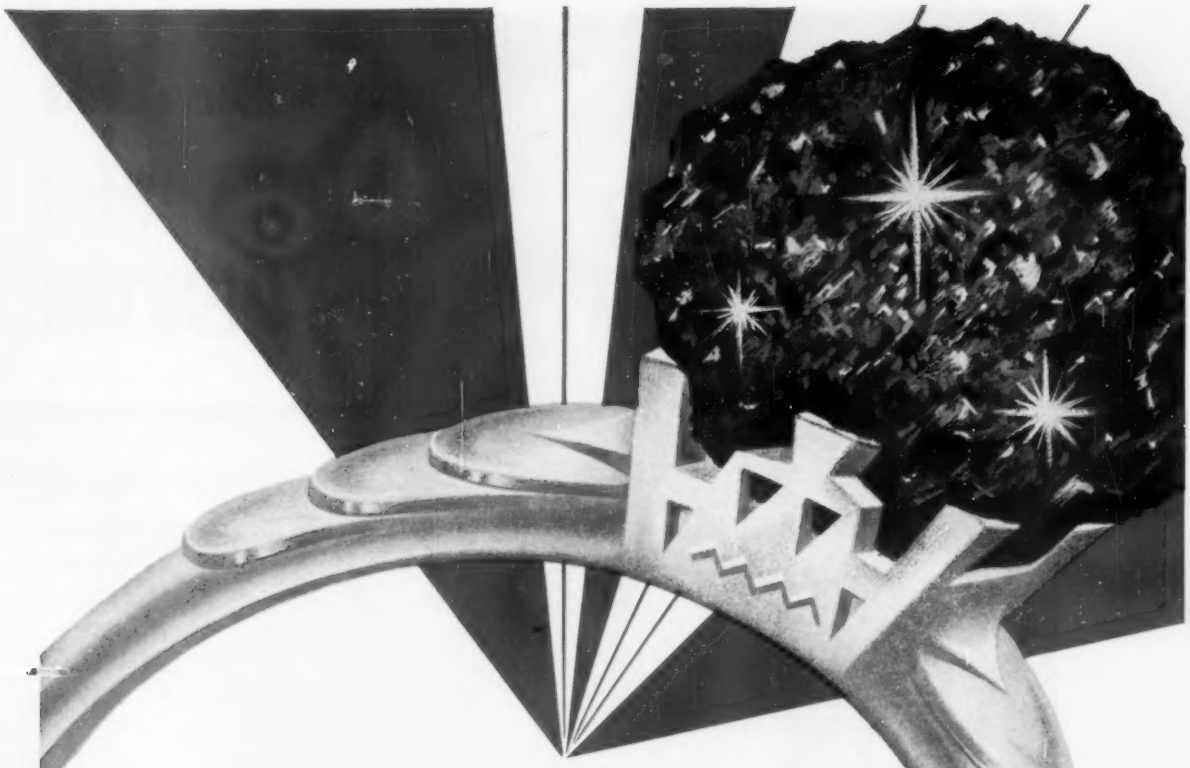
BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

1025 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal



Precious Jewel of Industry's Future

"Black Diamonds" are America's most valuable resource for today and tomorrow! Only Bituminous coal can fully meet industry's needs for more electrical energy and more plant-power.

Convenient reserves of B&O Bituminous offer an unlimited supply of coals for every purpose, at low-cost. *Ask our man!*

LET OUR COAL TRAFFIC REPRESENTATIVES suggest a B&O Bituminous for your needs.

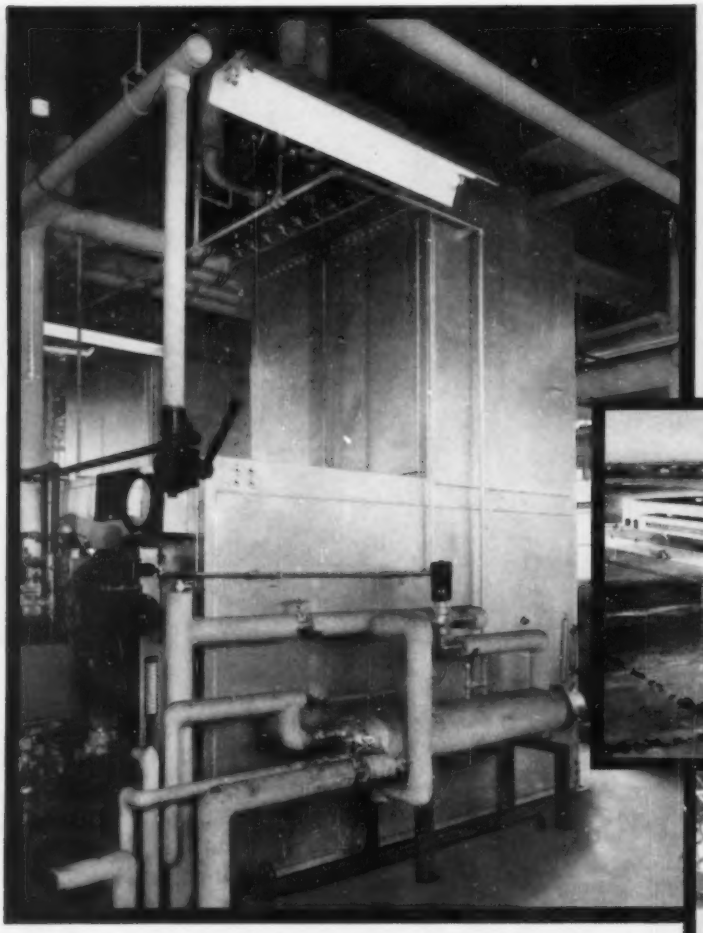
COAL TRAFFIC DEPARTMENT B&O RAILROAD
Baltimore 1, Md. LExington 9-0400

BALTIMORE & OHIO RAILROAD

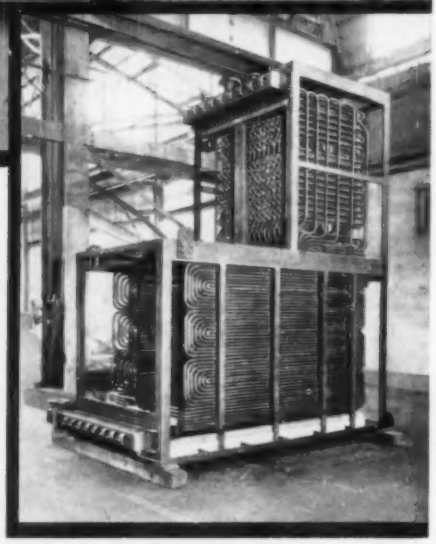
Bituminous Coals For Every Purpose

LINKING 13 GREAT STATES WITH THE NATION B&O ®

The Cross HIGH HEATING



C-E HT Boilers in service at the Cross Company. They are fired by oil or natural gas.



One of the two Cross Company boilers being assembled in the C-E shops.

THESE ARE THE GENERAL ADVANTAGES OF HIGH TEMPERATURE WATER:

1. Higher available heat — many times that of steam at the same pressure.
2. Closer control of temperature.
3. Lower heat loss . . . unused heat returns to the boiler . . . no condensate return lines.
4. No elaborate feedwater treatment . . . make-up requirements are exceptionally low.
5. Steam traps not required . . . trap problems and expense are eliminated.
6. No blowdown losses . . . no safety valve vent losses . . . no condensate losses.

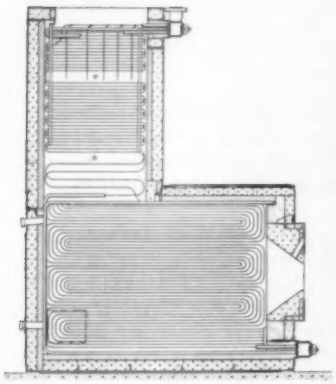
THESE ARE THE SPECIFIC ADVANTAGES OF THE C-E "HT" WATER BOILER:

1. Complete control over circulation in both system and boiler.
2. No separate boiler pump is required, since low pressure loss is inherent.
3. Pressurized operation with oil or gas means no induced draft fan.
4. Single-pass design—no baffles—means cleaner boiler and lower draft loss.
5. Controlled, positive circulation permits more efficient arrangement of heating surfaces.
6. Any fuel—oil, gas, coal, or any combination of fuels.
7. Gastight, welded steel casing.
8. Fewer headers, all of which are easily accessible.

Company specifies–

TEMPERATURE WATER BY C-E FOR ECONOMY...LOW MAINTENANCE

Architect's drawing of the new Cross Company plant, Giffels and Vallet, Detroit, Consulting Engineers; Owen S. Lieberg, Associated Consultant.



Combustion HT Water Boilers are available in sizes from 10- to 300-million Btu per hour. Drawing shows one of the 12-million Btu/hr. Cross Company boilers.

The Cross Company, pioneer producer of automation machinery, has recently completed an ultra-modern plant in Fraser, Michigan – practically doubling its former production capacity. After a thorough study of heating requirements . . . and with a view toward further expansion . . . two C-E LaMont Controlled Circulation Hot Water Boilers were specified for the new plant. According to Mr. W. P. Reece, Plant Engineer, "the study indicated that this system would provide the lowest fuel and maintenance costs . . . Experience during this winter confirms the soundness of our decision."

The C-E LaMont Controlled Circulation Hot Water Boiler is available in sizes ranging from 10- to 300-million Btu per hour, with pressures up to 500 psi and temperatures to 470°F – or higher if required.

If you are in the market for a heating or process system, it will pay you, too, to investigate high temperature water. Individual needs vary, of course, and both hot water and steam boilers have their place. Our engineers will be pleased to discuss the subject with you or your consultants. Write for our catalog HCC-2.

COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.
CANADA: COMBUSTION ENGINEERING-SUPERHEATER LTD.

C-E

B-990

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

A Record Unmatched In The Industry . . .

In *Every One* of the Nation's "Top Six"* Steam Power Plants, Fly Ash Control is by *Western Precipitation!*

As most power plant executives know, the Federal Power Commission annually "rates" the major steam power plants of the United States to determine their overall thermal efficiency as represented by their heat rate (i.e., BTU of fuel consumed per KWH of generated power).

*The "Top Six" steam plants according to the most recent Federal Power Report are . . . 1. Kyger Creek Plant (Ohio Valley Electric) . . . 2. Clifty Creek Plant (Indiana-Kentucky Electric) . . . 3. Kanawha River Plant (Appalachian Electric Power) . . . 4. St. Clair Plant (Detroit Edison) . . . 5. Muskingum River Plant (Ohio Power) . . . and 6. Tanners Creek Plant (Indiana and Michigan Electric).

We at Western Precipitation Corporation, take great pride in the fact that—in EVERY ONE of these "Top Six" plants—the equipment selected for fly ash control is WESTERN PRECIPITATION equipment.

Could there be any greater testimony to the outstanding superiority and unsurpassed efficiency of Western Precipitation fly ash control equipment?

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases . . and Equipment for the Process Industries

Main Offices: **1022 WEST NINTH STREET, LOS ANGELES 15, CALIFORNIA**

Chrysler Building, New York 17 • 1 North La Salle Street Building, Chicago 2 • Oliver Building, Pittsburgh 22 • 3252 Peachtree Road N. E., Atlanta 5 • Hobart Building, San Francisco 4

Precipitation Company of Canada Ltd., Dominion Square Building, Montreal

Representatives in all principal cities

Hall Industrial Water Report

VOLUME 5 JUNE 1957 NUMBER 3

Water Causes Trouble Everywhere

We in the United States do not have a corner on problems connected with water. Consequently, Hall Laboratories through the years has become international. Hall staff engineers now assist in the solution of water problems the world over, working with plants from Newfoundland to Chile and from the West Indies to Europe and the Middle East.

Trouble Shooting In Venezuela

When a Venezuelan utility plant fired up a temporarily idle boiler for service, the operators were surprised to find that a number of tubes were leaking. Further inspection revealed that they were badly pitted.

The surprise of the operators was understandable because boiler water analyses during the work week for the previous 18 months had shown adequate concentrations of alkalinity and sodium sulfite for prevention of corrosion. Furthermore, tests showed dissolved oxygen in the feedwater to be zero.

Hall staff engineer J. E. Summerville made a hurried trip to the plant to determine the cause of the trouble. The pitting nature of the corrosion belied the absence of dissolved oxygen from the boiler feedwater and the presence of adequate amounts of sodium sulfite in the boiler water. Hence, his investigation was directed toward finding out how oxygen was getting into the boilers.

The source of oxygen was quickly located. All boilers were shut down each week end. Air could enter the steam drums when steam pressure dropped. Moreover, with no steam available for the deaerator, any water pumped into the boilers was not deaerated. No water testing was done over week ends.

Changes were instituted immediately to avoid pumping undeaerated water into the boilers and to build up high concentrations of sodium sulfite in the boiler water for week ends. The problem which seemed so puzzling was simply diagnosed and solved because of the specialized experience of the Hall Engineer.

Water is your industry's most important raw material. Use it wisely.

Dirty Cooling Towers Impair Efficiency

Scale formation in the oil coolers and heat exchangers of the recirculating cooling system for diesel engines caused frequent outages and inefficient performance of equipment at an electric generating plant in Haiti. Scale had even formed in the cooling towers.

Untreated city water was normally used as makeup for the cooling system. When it was in short supply, however, water from deep wells was substituted. Analyses indicated to Hall staff engineer A. M. Henricks that both waters were scale-forming in character. He recommended that the water be stabilized against deposition of scale by threshold treatment with Calgon,® supplemented with some sulfuric acid to hold alkalinity of the recirculated water at a satisfactory level.

Algae and bacteria growths in the system were prevented by disinfection with calcium hypochlorite.

Again, trouble-free operation was simply accomplished because of the specialized knowledge and experience of the Hall Engineer.

All Not Left to Kismet

Heavy iron oxide deposits in the boilers of a large Middle East oil company caused many tube failures and costly unscheduled outages.

A study of the problem showed the source of the iron oxide to be corrosion in the condensate return system. Since carbon dioxide in the steam was a factor in the corrosion, some consideration was given to decarbonation of evaporator feedwater with sulfuric acid. However, this would have involved a substantial investment for equipment as well as careful chemical control and operation. Hall staff engineer A. M. Henricks accordingly recommended the use of Hagafilm,® which effectively controls corrosion of metal surfaces contacted by condensate even though the condensate contains dissolved carbon dioxide and oxygen.

The Hagafilm feed did all that was asked of it. It stopped the corrosion and cleaned up the system so effectively that the plant reported "deposits in the boilers have been so light during recent inspections that semi-annual inspections have been discontinued."

Cemented Relations

The heading might apply to the harder-than-concrete complex aluminum silicate scale which was causing loss of boiler tubes in a Colombian oil refinery.

Lake water used in the boilers contained a lot of iron. Coagulation with alum followed by ineffective filtration did not remove the iron. Instead, a considerable amount of aluminum from the alum passed through the filters in the water and went to the boilers causing formation of the complex aluminum silicate scale.

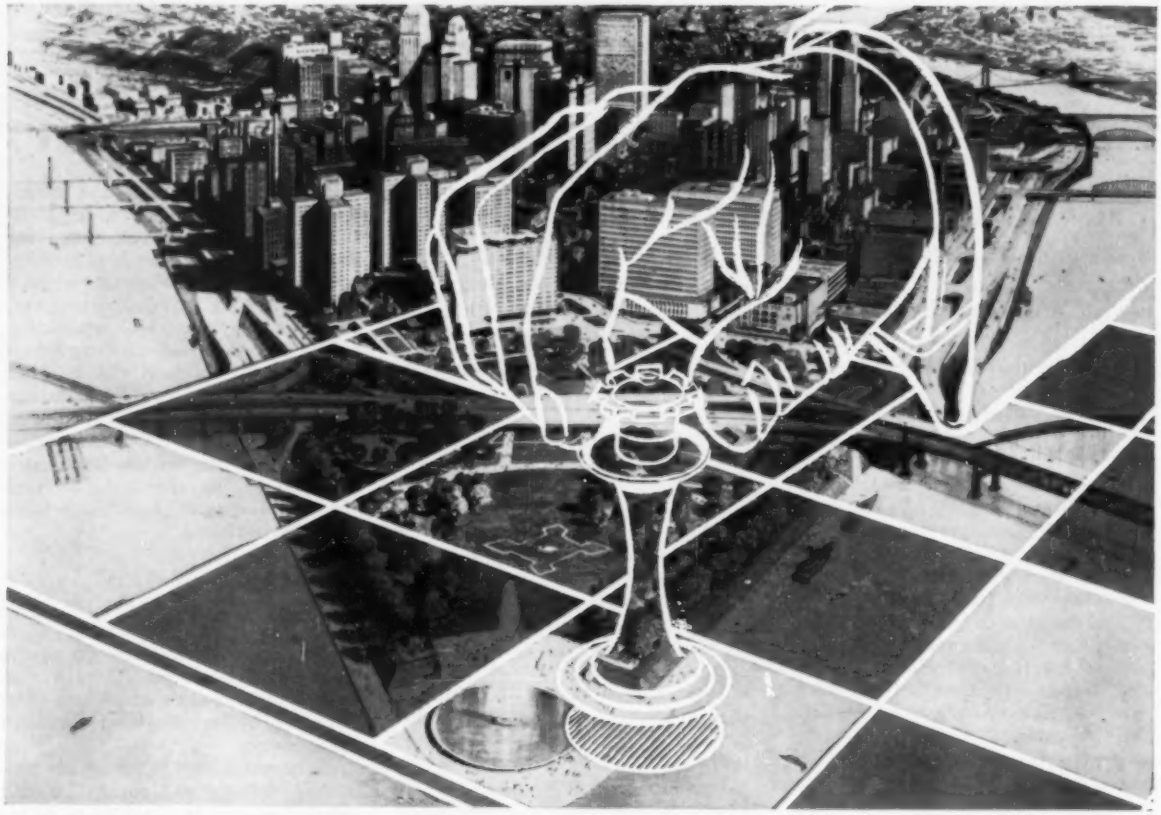
A solids-contact clarifier which had been installed to treat water for a recirculating cooling system was not being used. At Hall's recommendation a few mechanical changes were made to adapt the equipment to treatment of the boiler feedwater. This made possible successful clarification and removal of iron from the water without contaminating the effluent with aluminum.

Now, "cemented" applies to relations between Hall Laboratories and the plant rather than to the scale in the boilers.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information, write, wire or call Hall Laboratories, Division of Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Pa.

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water



Smart Move - Smart Engineer

An exciting career with WESTINGHOUSE —First in Atomic Power . . .

A wonderful way of life in PITTSBURGH —Renaissance City of America

It's the wise engineer who is making the move to WESTINGHOUSE—PITTSBURGH. Not only is he contributing his talents to the important task of building America's ATOMIC FLEET, but he is experiencing the wonders of living in the NEW Pittsburgh. No city in the United States has undergone the metamorphosis of this great metropolis; and the extraordinary results are evident everywhere—from the new, safe, wide highways to the delightful tree-lined, residential communities. For a way of life that is truly fit for a "king," the smart move is to PITTSBURGH, and an ATOMIC POWER career with WESTINGHOUSE.

Send your resume to: Mr. John D. Batey, Dept. #M-12
Westinghouse Electric Corporation
P. O. Box 1047, Pittsburgh 30, Penna.

Responsible positions that offer immediate opportunities.

NO DELAYS AWAITING SECURITY CLEARANCE.

ELECTRICAL ENGINEERS

Degree; design, application, test and analysis of instrumentation and control systems and components.

MECHANICAL ENGINEERS

For liaison. Power Plant machinery layout. Some stress, supervise final installation. Degree required.

HEAT EXCHANGER ENGINEERS

Mechanical engineers for design and manufacturing follow of heat exchangers and steam generators for high pressure service. Degree required.

MANUFACTURING ENGINEERS

Experienced pumps, valves. Work as liaison between engineering department and venders on centrifugal pumps and other semi-standard centrifugal and positive placement pumps and valves.

METALLURGICAL ENGINEERS

Responsible for materials and processes application to marine nuclear power plants.

Westinghouse
ELECTRIC CORP.

Research-Cottrell 1956 Orders for 20 Central Station Precipitators

Consolidated Edison Company
STATION: ASTORIA • UNIT NUMBER: 3

Consolidated Edison Company
STATION: ARTHUR KILL • UNIT NUMBER: 2

New England Power Company
STATION: SALEM HARBOR • UNIT NUMBER: 3

A Prominent Southeastern Utility
2 PRECIPITATORS

Tampa Electric Company
STATION: GANNON • UNIT NUMBER: 2

Union Electric Company of Missouri
STATION: MERAMEC • UNIT NUMBER: 3

A Prominent New England Utility
1 PRECIPITATOR

New York State Electric and Gas Corporation
STATION: MILLIKEN • UNIT NUMBER: 2

Public Service Electric and Gas Company
STATION: BERGEN • UNIT NUMBER: 1 AND 2

The Hartford Electric Light Co.
STATION: MIDDLETOWN • UNIT NUMBER: 2

Virginia Electric and Power Company
STATION: CHESTERFIELD • UNIT NUMBER: 2

Delaware Power & Light Company
STATION: INDIAN RIVER • UNIT NUMBER: 2

Commonwealth Edison Company
STATION: FISK • UNIT NUMBER: 19

The Detroit Edison Company
STATION: ST. CLAIR • UNIT NUMBER: 6

Research-Cottrell

RESEARCH-COTTRELL, INC., Main Office and Plant: Bound Brook, New Jersey • 405 Lexington Ave., New York 17, N. Y.
Grant Building, Pittsburgh 19, Penna. • 228 No. La Salle St., Chicago 1, Ill. • 111 Sutter Bldg., San Francisco 4, Cal.

RC174

FOR COAL BUNKER NOSES, CHUTES, HOPPERS, SPREADERS THAT MATCH THE LIFE OF YOUR BOILER...

Take a long look at Lukens clad steel

This is Lukens clad steel... not a lining, not a soldered-on surface, but a solid plate—one side corrosion resistant stainless steel permanently bonded over all to a rugged backing steel.

Its durability in coal handling equipment is proved by installations 10 years old which show no measurable wear. It effectively cuts hangups—as well as damage from sulfuric acid in wet coal—to the vanishing point.

PLUS: ready fabrication, reduced maintenance, freedom from down time, and easy modification. And Lukens will help you and your fabricator select the proper types and gages to meet your needs.

Bulletin 740 will give you performance facts and production information. For this bulletin, as well as the names of experienced coal handling equipment builders, write Manager, Marketing Service, 939 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

LUKENS®

Helping industry choose steels that fit the job

BEACON COAL

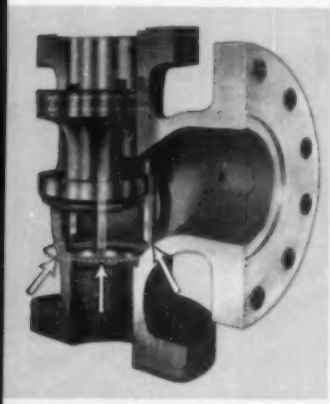
EASTERN GAS AND FUEL ASSOCIATES

PITTSBURGH • BOSTON • CLEVELAND • DETROIT • NEW YORK
NORFOLK • PHILADELPHIA • SYRACUSE

For New England: New England Coal & Coke Co., For Export: Castner, Curran & Bullitt, Inc.

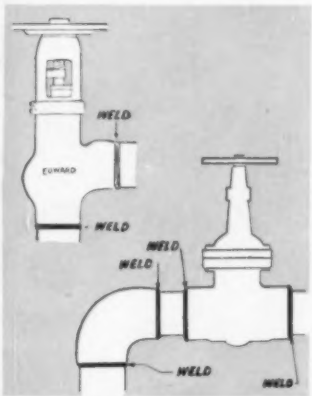
How To Get The Most

Tips on selection, installation and operation of steel



INTERNALLY-GUIDED VALVES MORE EFFICIENT

Internally-guided stop, check, and non-return valves are more efficient if the disk centers into the seat for positive shut-off. Illustration shows typical Edward check valve with three integral guide ribs.



ANGLE VALVES REDUCE INSTALLATION COST

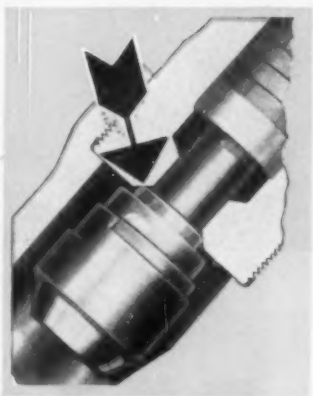
An angle stop valve can often be used instead of an elbow and a globe or gate valve. This reduces installation cost, makes bends, elbows and other components unnecessary, minimizes pressure drop.

STREAMLINING CUTS FLOW RESISTANCE

Internal streamlining, carefully designed and executed, cuts turbulence . . . reduces pressure drop . . . minimizes wear. Working with experimental half-models and the most modern laboratory equipment, Edward scientists incorporate the most precise streamlining in every valve.

BACKSEAT ISOLATES PACKING CHAMBER

Stop, non-return and blow-off valves can actually be repacked under pressure if they have a positive backseat, as illustrated. Here, a radiused disk nut contacts beveled bonnet seating surface, isolates packing from line pressure. This feature also protects packing, and reduces maintenance.



WELDED BONNET CAN'T LEAK

Ideal for severe service applications, small forged valves with welded bonnets are virtually leak-proof. This construction permanently maintains pressure tightness—eliminates need to periodically restress bolts. Weld can be removed, however, if internal repairs are ever necessary.

HERE'S BEST WAY TO BLOW DOWN

To begin blow-down, open wide the valve nearest boiler—then open second valve. To stop blow-down, reverse procedure by closing second valve first—then close valve nearest boiler. This puts greatest wear on second valve, which can be repaired or replaced *without shutting down boiler.*

Rockwell-Built Edward Valves

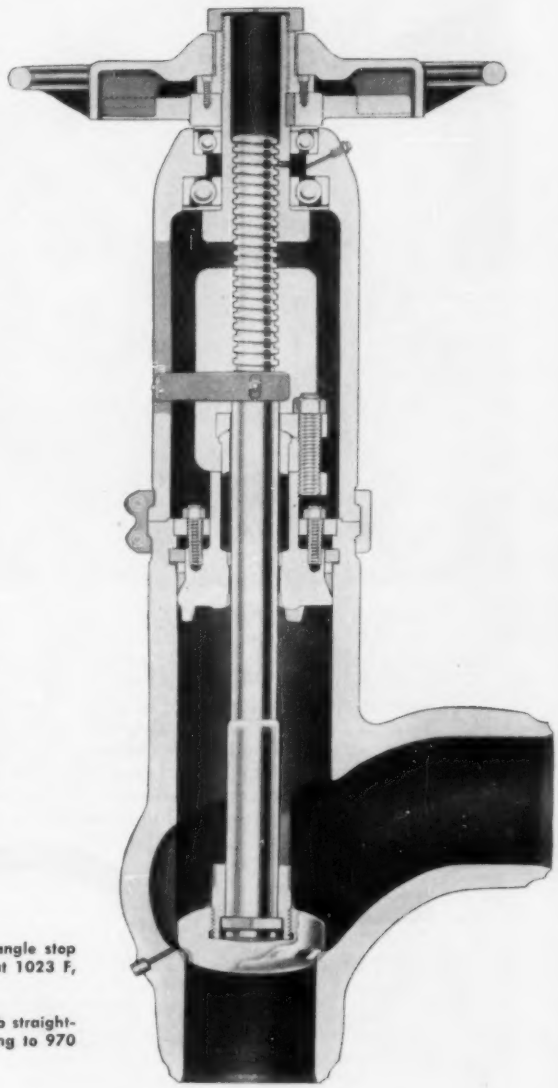
Value From Steel Valves

valves from Edward, long-time leader in the field

One way to cut the cost of initial installation—and future maintenance expense—of a piping system is to select the *right* steel valves. A competent valve engineer, for example, can often indicate where one angle stop valve can replace both an elbow and a globe or gate valve . . . reducing the costs of installation *and* cutting the number of piping components required. Other typical "secrets" of obtaining greater value from steel valves are shown in convenient clip-out form on the opposite page.

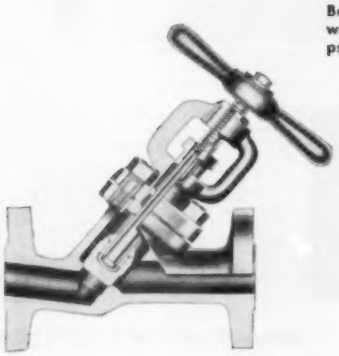
While he is well acquainted with piping conditions, a valve engineer concerns himself primarily with valves and their functions—and in this field, he is an acknowledged expert. His field experience, plus access to the results of continuous laboratory research, can put at your disposal a wealth of information on valve selection, installation, operation, maintenance and repair.

Such a man is your Edward Valve Representative. Technically trained, thoroughly experienced, his professional advice can save you headaches and money. At his disposal and yours are the results of continuing substantial investments in steel valve research. Many features, now accepted as standard in valves, were actually introduced by Edward. This process of constant development is reflected in Edward Valves . . . and in the spirit of your Edward Representative! He is at your disposal, to help you obtain the *most* for your valve dollar—both now and in the future. A card or a call will bring him . . . why not get in touch with us now?



Right: Fig. 7517Y cast steel 1500 lb angle stop valve for steam services to 1500 psi at 1023 F, water to 3600 psi at 100 F.

Below left: Fig. 641 forged steel 600 lb straightway blow-off valve for boilers operating to 970 psi saturated drum pressure.



Edward Valves, Inc.

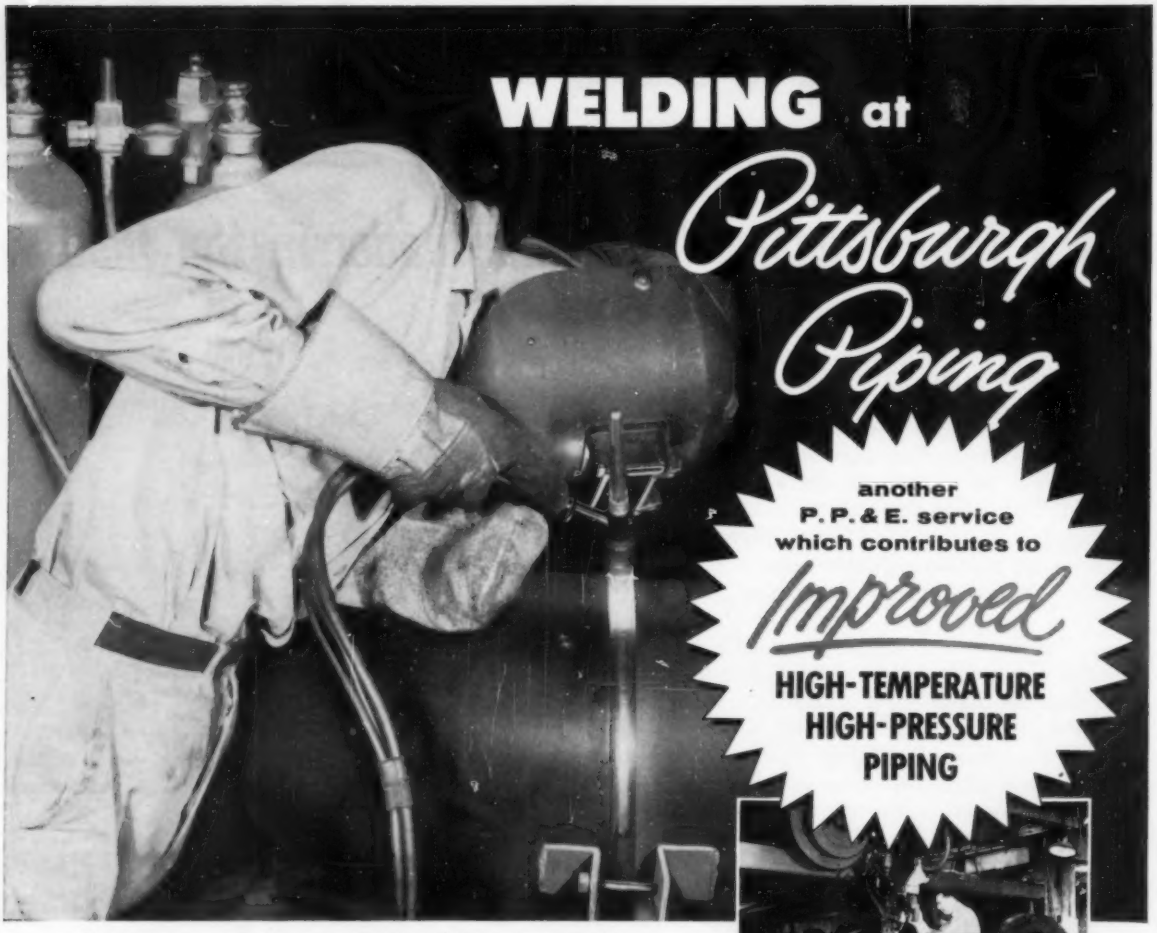
Subsidiary of ROCKWELL MANUFACTURING COMPANY

1206 WEST 145TH STREET

EAST CHICAGO, INDIANA

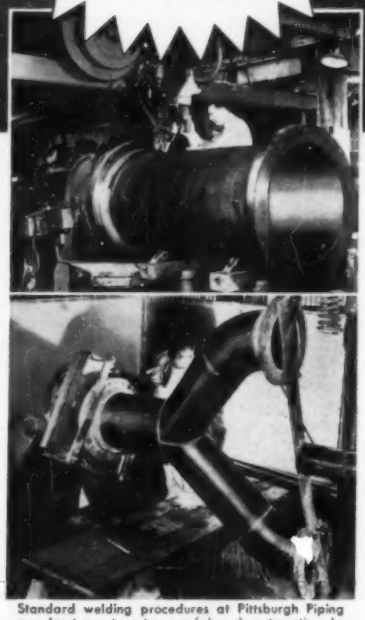
WELDING at Pittsburgh Piping

another P. P. & E. service which contributes to Improved HIGH-TEMPERATURE HIGH-PRESSURE PIPING



Modern power and process piping fabrication requires the highest degree of welding skill, as well as technical supervision which provides complete control of welding procedures. All Pittsburgh Piping welders and welding operators are performance qualified in accordance with Standard A.S.M.E. Welders' Qualification Test. They are specially trained in the exacting requirements of fabricating piping and related equipment for high-temperature, high-pressure central station service, corrosion-resistant applications, and nuclear power installations.

Fabricated high pressure boiler feed piping shop fabricated at Pittsburgh Piping. Comprises bends and forged laterals.



Standard welding procedures at Pittsburgh Piping are: Inert gas tungsten arc (above); automatic submerged arc (center); and manual metallic arc (bottom).

PRODUCTS AND SERVICES

Carbon Steel Piping	Forged Piping Materials
Cast Iron Fittings	Headers
Cast Steel Fittings	Manifolds
Chrome-Moly Piping	Pipe Bends
Copper Piping	Stainless Steel Piping
Corrugated Piping	Van Stoning
Creased Bends	Welded Assemblies
Expansion Bends	Welded Stainless Steel Tubing
Flanges	Welding Fittings

PP-20

Pittsburgh Piping AND EQUIPMENT COMPANY
158 49th Street — Pittsburgh, Penna.
CANADA: CANADIAN PITTSBURGH PIPING, LTD.
835 BEACH ROAD—HAMILTON, ONTARIO

OFFICES IN PRINCIPAL CITIES

Atlanta	Whitehead Building
Boston	10 High Street
Chicago	Peoples Gas Building
Cleveland	Public Square Building
Hollywood	1828 North Alexandria Ave.
New Orleans	P. O. Box 74
New York	Woolworth Building
Syracuse	113 So. Salina Street
Toronto	68 Yonge Street

structural details?

. . . many things.

And all make air preheating with a Ljungstrom more economical, less troublesome. The Ljungstrom offers these refinements:

- The welded steel rotor is strong enough to support the heating elements without strain, yet flexible enough to withstand extreme temperature variations.
- An inspection port and strategically located access doors reveal any maintenance needs and make replacement work routine.
- A mass flow soot blower is installed as original equipment at the cold end where deposits are most apt to accumulate.
- The hot end heating surface is made from open hearth steel sheet and the cold end from heavier gauge, low-alloy corrosion-resisting material because corrosion is normally confined to the cold end.

The Air Preheater Corp. is constantly working to improve Ljungstrom heating surfaces, seals, bearings, and other structural details. And, in general, these improvements can be applied to existing units with only minor changes and at nominal cost. Another reason why seven out of ten air preheating installations are Ljungstrom. For the full story on how the Ljungstrom design and construction can cut your fuel costs, increase plant efficiency, write for our 38-page manual.

The Air Preheater Corporation, 60 EAST 42ND STREET, NEW YORK 17, N. Y.

...more facts about APEXIOR® NUMBER 1®

. . . AND HEAT TRANSFER

Moving heat to water through boiler steel was never a more critical process than now. Yet the inside of a boiler is still "home" to Apexior Number 1 — the coating that grew up with today's high-pressure boiler. No barrier to b.t.u.'s, Apexior has, in fact, been speeding them on their way for fifty-one years to establish itself as a highly effective heat-transfer medium.

Theory, too, has proved Apexior. It has been demonstrated that surfaces transferring heat most efficiently to liquid produce uniform small bubbles — and that Apexior-coated surfaces better the performance of bare steel by producing more bubbles, more evenly distributed.* Here, then, is a medium that moves maximum heat to destination — and in the process even betters the evaporating characteristics of boiler steel.

. . . IN STANDBY SERVICE

Your boiler may be idle — but never Apexior. Off the line, too, it's on constant duty preventing the rapid deterioration that so often plagues out-of-service boilers. Operating engineers today as always Apexior-coat — with full boiler insurance company approval — boilers scheduled for dry standby. It's an easy way to keep them safe from corrosive attack and ready always for steaming service.

. . . AND HIGH-PURITY STEAM

One of Apexior's longest service records outside the power plant is its food-industry use in direct contact with sugar juices and liquors in evaporators, clarifiers and separators. A chemically inert surface of Apexior Number 1 inside a boiler assures dependable steam for any processing need.

. . . AND FEEDWATER TREATMENT

Is Apexior necessary when feedwater is treated? Thousands of power engineers who combine chemistry's contributions to steam generating efficiency — feedwater treatment and Apexior protective surfacing — do so because they know each makes a distinct contribution to boiler performance.

While boiler water can be improved, it is generally agreed not even the best water improves boiler steel. The task, then, is to hold the line against an element potentially destructive to steel. Apexior does just that, building into tubes and drums an operating factor of safety not otherwise obtainable. Should conditions ever deviate from the ideal, Apexior takes the consequences while steel, safely isolated, stays strong and sound.

These are some of the reasons why Apexior Number 1 is manufactured today in the United States and four foreign countries for use the world around in . . . *boiler tubes and drums • evaporators • deaerating and feedwater heaters • steam turbines* •

This message is one of a continuing series. Watch for the answer to your question, or write

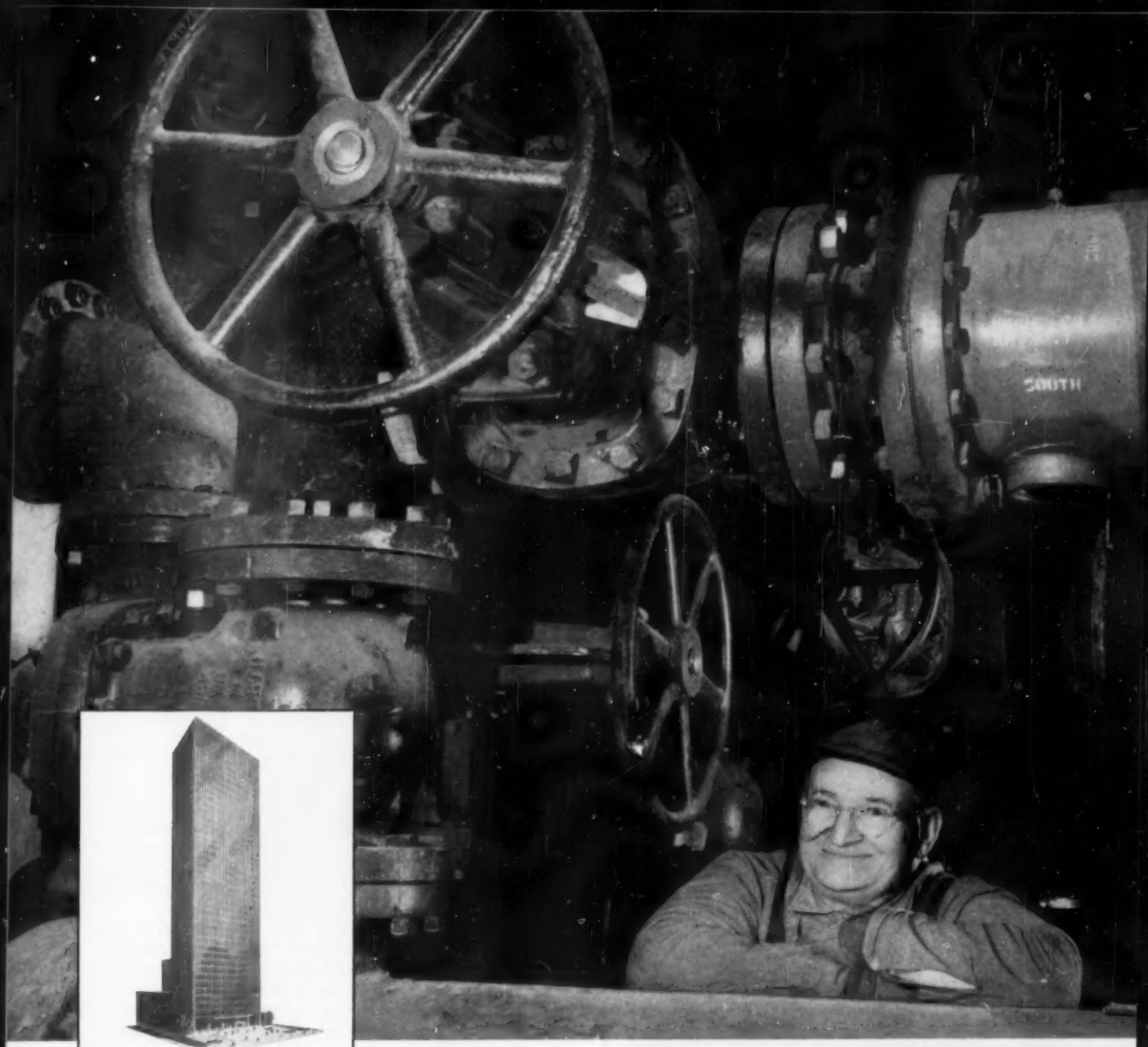
MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

HYDE PARK, BOSTON 36, MASSACHUSETTS

*by Dr. Max Jakob, in his study, "Heat Transfer in Evaporation and Condensation." Data on request.

204



Owner:	House of Seagram, Inc.
Architects:	Mies van der Rohe & Philip Johnson
Associate Architects:	Kahn & Jacobs
Consulting Engineers:	Jaros Baum & Bolles
General Contractor:	George A. Fuller Company
Plumbing Contractor:	Eugene Duklauer Inc.
Mechanical Contractor:	Kerby Saunders Inc.

"In the new Seagram building it's 100% Walworth Gate, Globe, and Check Valves"

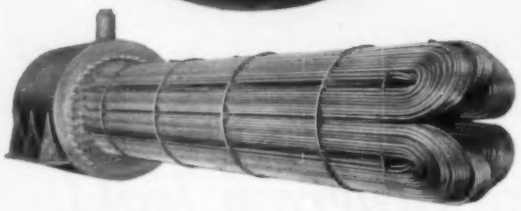
WALWORTH 60 East 42nd Street, New York 17, N. Y.

COMPLETE LINES OF STEEL, IRON, AND BRONZE VALVES AND PIPE FITTINGS

Distributors in principal centers throughout the world

Walworth Subsidiaries: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTING CO. • SOUTHWEST FABRICATING AND WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

Highest Standard in Boiler and Pressure Tubing



Every length of Standard Boiler and Pressure Tubing is tested at pressures far beyond code requirements and can be readily bent or otherwise fabricated.

Electric welded boiler tubing is used today by all of the leading manufacturers of boilers and superheaters—stationary, marine, and locomotive—high or low pressure—and meets the requirements of government and commercial specifications.

With recent changes in the A.S.M.E. Boiler Code, it's now possible to use electric weld boiler tubing at pressures in excess of 2,000 lbs. High strength "Grade C" tubes are available for even higher pressures.

Uniformity of temper and wall thickness makes Standard tubes easier to roll for tight . . . sure fit. Standard's fine, smooth surface eliminates any need to polish ends for tight fit. Even a microscope won't spot the exact location of the weld.

Nowhere will you find any more modern and complete facilities for precision manufacture and inspection of Boiler and Pressure Tubing than you'll find at Standard.

For complete information on all Standard products and services send for free 8-page folder today.

Free 8-page folder on all Standard products. Write address below.

STANDARD

THE STANDARD TUBE COMPANY

24400 PLYMOUTH ROAD • DETROIT 39, MICHIGAN

Welded stainless tubing and pipe • Welded carbon steel mechanical • Boiler and Heat Exchanger • Exclusive rigidized patterns • Special Shapes • Steel Tubing – Sizes: ⅛" OD to 5½" OD – .028 to .260 wall • Stainless – Sizes: ¼" OD to 4½" OD – .020 to .165 wall.

boiler water levels now easier to **see**... easier to **read**

Whatever the boiler pressure, high or low, YARWAY Remote Indicators give accurate, instant, eye level boiler water level readings at any convenient plant location.

Boiler Code Case No. 1155* says in part, "... two independent remote level indicators of the compensated manometric type may be used instead of one of two required gage glasses for boiler drum water level indication in the case of power boilers with all drum safety valves set at or above 900 psi..."

YARWAY Remote Liquid Level Indicators fill the bill—and feature a "wide vision" face that makes reading easier from any angle.

Accurate—because indicator is actuated by the boiler water itself—by the pressure differential between a constant head and the varying head of water in the boiler drum.

Also use YARWAY Remote Indicators on heaters of various types.

For full description, write for YARWAY Bulletin WG-1824.

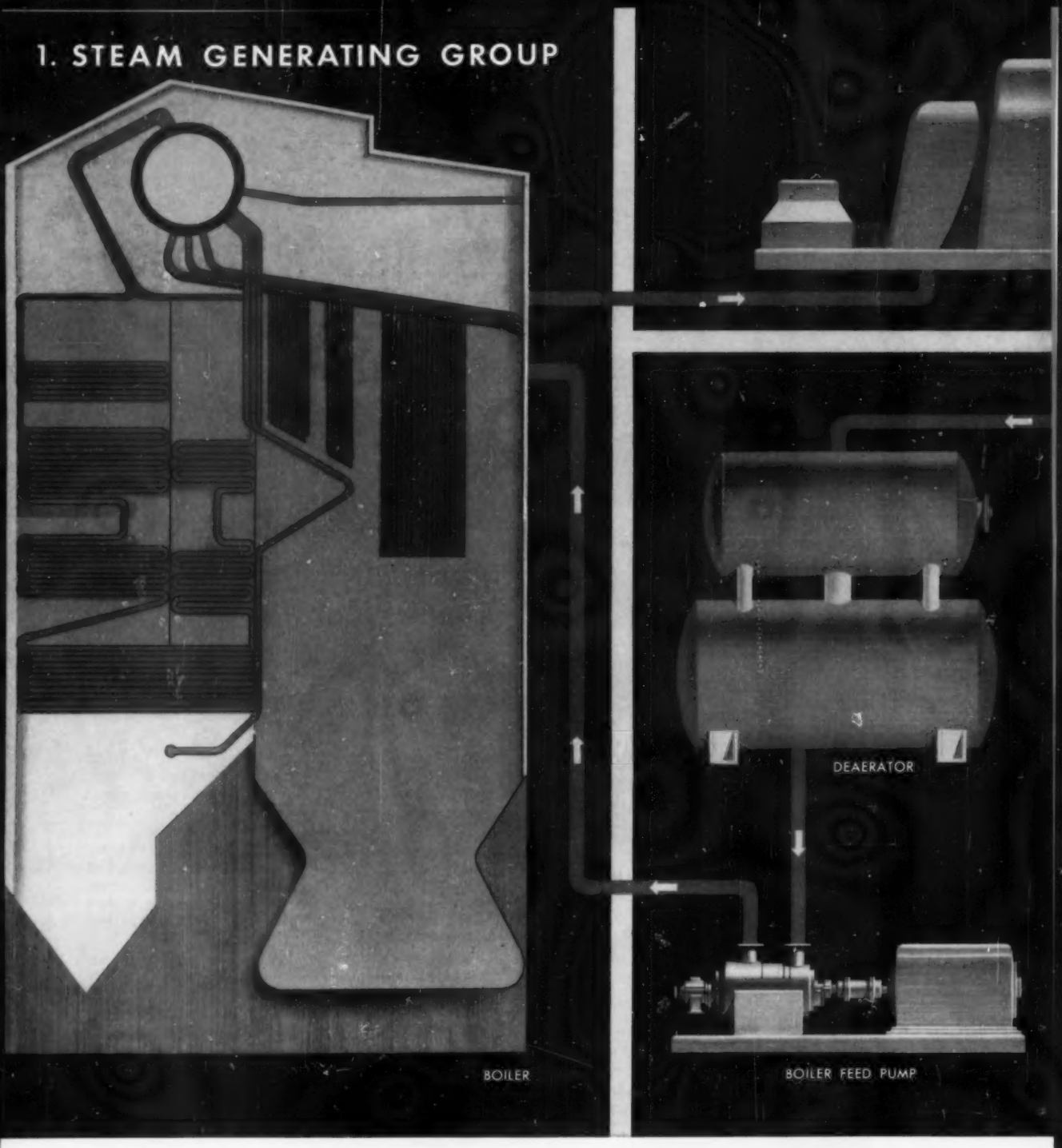
*Write for free reprint of case description.

Yarway Remote Hi-Lo Alarm Signals—lights or horns—can be used with Yarway Remote Liquid Level Indicator and placed at any location in the plant.

YARNALL-WARING COMPANY

100 Mermaid Avenue, Philadelphia 18, Penna.
BRANCH OFFICES IN PRINCIPAL CITIES

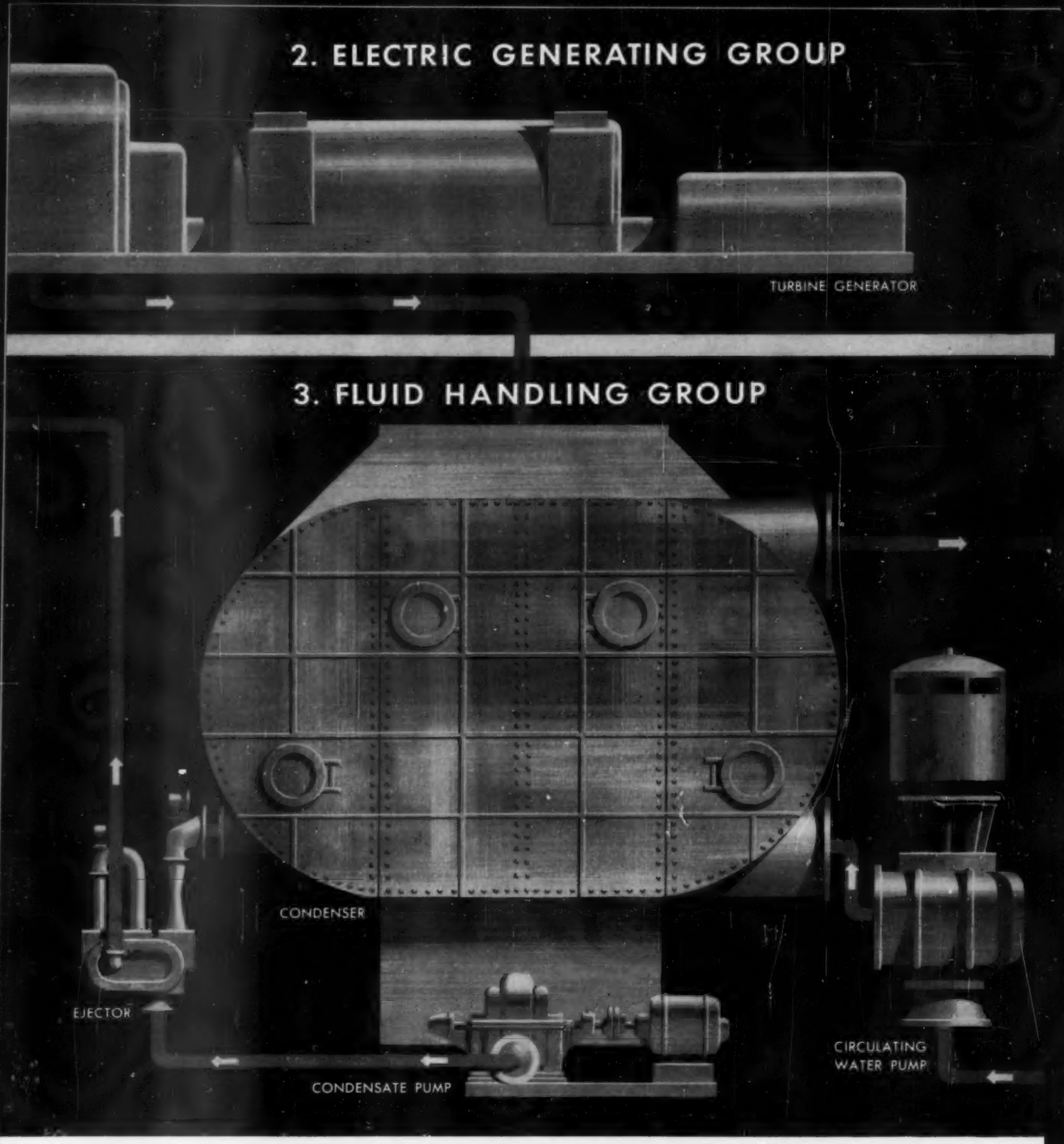
YARWAY REMOTE LIQUID LEVEL INDICATORS



Look at all three

A new steam station design approach is bringing higher efficiencies, lower costs, and greater reliability. In this approach, only three basic functions are considered: (1) Steam Generating, (2) Electric Generating. (3) Fluid Handling. Station requirements are first analyzed in terms of the over-all job performed by each of these groups rather than by each individual piece of equipment.

Many of the benefits of this approach occur in the Fluid Handling Group. Here coordination and integration of the wide variety of equipment used can often effect substantial improvement in over-all operation. As steam temperatures and pressures go up, there are increased demands on the fluid handling function. Plant reliability often depends on the effect of one component of the fluid handling group on another during operational transients, either planned or of emergency nature. The solution is coordinated equipment



for power!

selection, engineering and design. And Worthington's "system" know-how and experience with modern complex plant cycles can help solve your fluid handling problems.

System-wise experience As the manufacturer of all major components of the Fluid Handling Group, Worthington has a reservoir of experience and knowledge that can be of benefit to you. To put this "system-wise" experience to work for you, get in touch with your nearest district office. Or write to section C-71, Worthington Corporation, Harrison, New Jersey.

WORTHINGTON

Your "Cost" Dollars Come Back QUICKER...

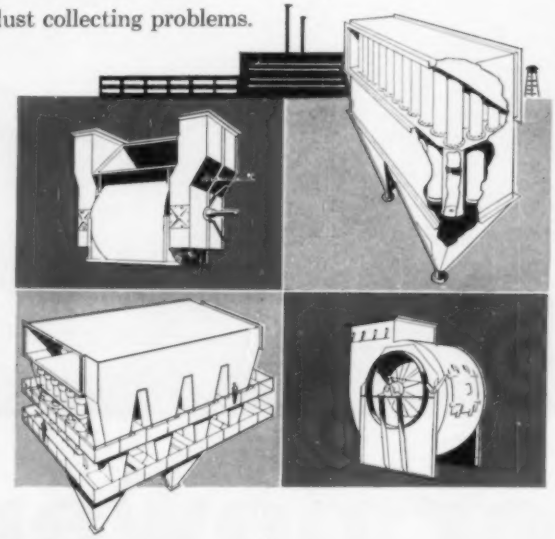
with WHIRLEX dust collecting equipment!

If you are concerned with nuisance elimination . . . or with the recovery of process material . . . WHIRLEX can help you. Our research laboratory, engineering and manufacturing facilities are *totally set up* and especially experienced to provide "dollar-saving" solutions to the most perplexing dust collecting problems.

Low original cost *plus* continuous, efficient operation and low maintenance of WHIRLEX equipment assure quickest return of cost dollars!

For a completely integrated and co-ordinated installation, the following shop-assembled equipment is available:

WHIRLEX Type CTF Mechanical Gas Centrifuge Collectors
WHIRLEX Type MTSA 9CYT Multiple Cyclone Collectors
WHIRLEX Induced Draft Fans · WHIRLEX Forced Draft Fans
Special Duct Work · Self-Supporting Stacks
Support Structures



FLY ASH WHIRLEX ARRESTOR

Write today for complete engineering data . . .

THE FLY ASH ARRESTOR CORPORATION

269 North First Street — **Birmingham, Alabama**

Symbol of the Highest Engineering Standards for Water Treatment Equipment

GRAVER WATER CONDITIONING CO., Division of Graver Tank & Mfg. Co., Inc.

216 West 14th Street, New York 11, New York I–310

A **Buell Cyclones** offer exclusive Shave-off which harnesses double-eddy currents and puts them to work, large diameter design which eliminates bridging and clogging.

B **Buell "SF" Electric Precipitator** delivers extra collection efficiency through use of unique high emission, selftensioning Spiralectrodes and exclusive Continuous Cycle Rapping.

C **Buell Combination Cyclone-Precipitator Systems** combine exclusive Buell features for extra efficiency where extremely high performance standards must be met.

Which is the best dust collection system?

Five factors influence the choice of a dust collection system: dust characteristics, gas characteristics, efficiency required, installation and operation costs, and limitations of space or draft loss. In every installation, exclusive Buell features provide *extra efficiency*. A booklet, "The Collection and Recovery of Industrial Dusts", provides valuable, specific details. Just write Dept. 70-F, Buell Engineering Company, Inc., 70 Pine Street, New York 5, New York

buell®

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

Editorial

Graduation Day—Planned and Plotted?

Of recent years graduation day, especially for engineering students, has become a matter of as pressing importance to industry as it has always been for the individual student. The sheer statistics of engineering graduates are closely studied, trends are plotted, recruitment programs planned. This June an estimated 30,000 students will receive engineering degrees as compared to 1956's class of 24,000 which indicates that American youth are responding to the appeals of industry for more and more engineering graduates.

Moreover as The Engineering Manpower Commission points out the tempo of interest in problems of technical manpower has increased markedly overseas as well. There is a universal concern about the supply of technical personnel. In addition some attempt has been made in most countries to estimate the needs for engineering personnel in relation to current developments and the probable future. Unquestionably such concern and the publicity attendant to it will have its effect upon the average youth. We can look for an increase in the number of engineering graduates for the next several years. If this assumption is correct can we not look also for a switch in student interest as other segments of American industry make their demands felt?

We think the answer to the above question is yes and we believe rightly so. But we recognize in the same breath that there are dangers inherent in such a cyclic response and particularly so for technical graduates. This class of student needs to lay the groundwork for his professional career very early, in fact, no later than at the start of his high school years. Remedial steps are in the making to revamp our educational system to put more emphasis on mathematics and science at the high school level so that this phase of preparation will be sound. This we believe is all to the good. Yet we must all recognize that not every youngster is fitted for engineering nor for that matter even interested in it. This poses a difficult problem.

Obviously most youngsters at the age of admission to high school are not ready nor able to appraise their own likes or abilities. Unfortunately the average school system can give but little help. They can apply only the most sweeping generalizations based on class room experience and grade school teachers' reactions as to a student's bent. Hence a recent announcement from the University of Wisconsin describing an experimental project to find superior students as they enter high school struck us as possibly a harbinger of secondary school practice of a few years hence. It is an attempt to establish a more scientific culling, so to speak.

Briefly the University of Wisconsin project takes the form of a guidance laboratory to which selected students of all fields of interest are sent for a two-day interview and testing session. The results of this session plus data from conferences with teachers and principals presumably suggest a course of study for the individual. Periodic checkups by tests at the University plus review of high school records and performances further guide the development of the student.

Out of this experiment should come a more knowing procedure of tests and interview techniques for locating, guiding and developing the superior student. Certainly it is to be hoped that this procedure will prove broadly applicable to all high schools including those not bolstered with the support of a large State university. Further, from just such an approach conceivably could come a better knowledge of the strengths of all our youth, not only the superior but the average as well.

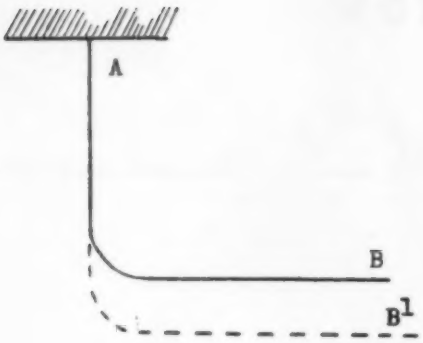


Fig. 1.—A pipe of configuration shown by solid line connected at "A" only assumes dotted line when heated

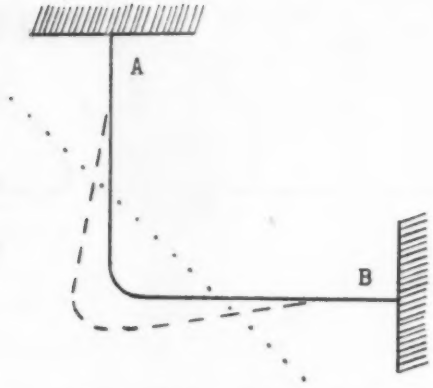


Fig. 2—By making both points "A" and "B" rigid the pipe upon being heated will assume the shape of the dotted line

NEMA Approves Piping Standards for

Steam turbines are high speed, precision, rotating machines with close tolerances and definite alignments between parts. External piping can introduce thrusts and reactions which upset this alignment. Hence NEMA has drafted approved piping standards to maintain these reactions within allowable limits

THE first consideration in designing any piping system is to keep the stresses in the pipe within the limits of established rules of national codes such as ASME Boiler Code, the ASA Code for Pressure Piping, and any local codes that may be applicable. In general, the jurisdiction of such authorities stops at the trip and throttle valve inlet flange, the exhaust flange, extraction opening flange, induction opening flange or other openings on the machine to which external piping systems connect.

When a piping system is connected to a steam turbine, there are additional limitations, and it is the purpose of these sections to discuss and define these limitations as an aid to the purchaser in designing such systems.

Steam turbines are high-speed precision rotating machines, often of large dimensions. They have been very carefully designed to provide for expansion and, at the same time, maintain close alignment between the rotating and stationary parts. The provisions for expansion of the casing and maintenance of close clearances necessarily limits the forces that can be applied to the turbine by the piping connected to it. Pipe reactions, if of sufficient magnitude, may result in misalignment of the turbine sufficient to affect economy, cause rough operation and serious mechanical damage.

To keep the strains due to forces and bending moments on the turbine connections, including the weight of the pipe, within allowable limits, the piping system design should be such that restraints and freedom for movement match the requirements of the turbine. Pipe forces which seem small may lead to large moments at the connections to the turbine and very large forces at the turbine supports.

The connections to be considered are the high-pressure steam inlet, the extraction connections, the low-pressure admission connections and the exhaust connection. Under some conditions, the other piping connections may require checking.

In practice, steam piping systems should be completely and thoroughly analyzed, including restraints, branch lines and the effect of the dead weights of the piping system.

Manufacturers are willing to review and comment on customer's piping systems based on their experience with a wide variety of installations.

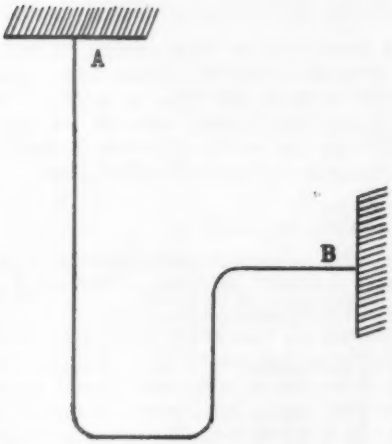
Steam Turbine Generator Units

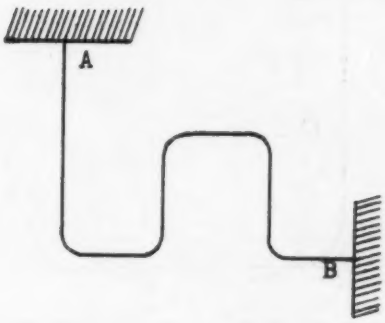
The following information outlines the basic principles and enumerates certain special requirements and suggestions for the design of steam piping attached to steam turbines. The numerical values given apply to steam turbine generator units rated 2000 kw to 10,000 kw inclusive.

The turbine is usually anchored adjacent to the exhaust casing. The high-pressure end is supported on a flexible plate or sliding support which permits motion along the turbine axis but not in the transverse or vertical direction. While the turbine is supported on or near its centerline, neither the inlet, exhaust or other connection is necessarily on the centerline, and, hence, these may move with temperature changes. In providing restraints to the piping and in providing for expansion in piping, the movements of the inlet, exhaust and other connections on the turbine must be taken into account.

Effect of Temperature Expansions on Piping Systems

If a pipe is connected to some point as "A" in Fig. 1 and has the configuration shown by the solid line, it will assume the position shown by the dash line when heated to a higher temperature, providing no restraint is offered by point "B". B′ shows the ultimate position.





Figs. 3 and 4—Expansion loops represent one way of reducing stress build-up within piping systems. Here are two samples

Industrial-Service Turbines

If both points "A" and "B" are rigid points which will not move, the pipe would assume the shape shown by the dash line in Fig. 2, when heated.

The stresses may be reduced by using expansion loops such as shown in Figs. 3 and 4. When the piping does not have to be confined to one plane, torsional flexibility may be effectively used to reduce stresses. Pre-stressing the pipe in the cold condition or cold springing may also be used to reduce the stresses in operation. These principles may also be used in combination to produce a design with flexibility enough to keep the stresses, forces and moments within permissible limits in both the hot and cold condition.

The piping system is best designed with sufficient inherent flexibility to take care of thermal expansion. The amount of piping can often be reduced by the use of "cold springing" to reduce or eliminate stresses due to thermal expansion. This is done by cutting the pipe short by a predetermined amount and then forcing it into place during installation, as illustrated in Fig. 5. Forces and moments in the hot condition are thus reduced below the values they would have if the system were not cold-sprung. Points A and C are the points to be connected by a piping system and ΔX and ΔY are the respective expansions.

In the case of welded connections, it should be understood that it is necessary to bend the pipe by putting a moment on it when connecting to point C to make the weld preparations parallel, as well as just pulling B up to C. If this is not done, a moment will exist in the hot condition, and only a partial cold springing job results. Wherever possible, it is wise to facilitate assembly by locating field welds at points of minimum moment. Points D and E are such points.

It may sometimes be necessary to provide additional flexibility at extraction openings, low-pressure admission openings, or non-condensing exhaust openings by the use of expansion joints. These should be avoided wherever possible but, if used, should be provided with stays to take up the pressure thrust.

Piping Supports and Guides

In guiding piping expansion movement to control forces and moments, there are two general methods available; namely, guiding by sliding or rolling surfaces and guiding by tie rods. Where tie rods are used, they have the advantage of minimum friction without sliding surfaces and are easily adjusted. Where sliding surfaces must be used, provision must be made to prevent galling. In either case, excessive friction should be avoided.

Adequate hangers should be provided to carry dead weight without restricting expansion and contraction. Under unusual circumstances, resonant vibration may occur. This can usually be corrected by changing the location of hangers or by adding extra stays or other devices where necessary.

In most piping systems, constant support hangers are used to support the dead weight of the pipe. In order to minimize any horizontal force components of the dead weight or any binding of the pin or rocker joints used on the hangers, the hanger rods should be as long as possible. Adequate length may prove to be difficult in the cases where a long horizontal run of pipe is a few feet below the turbine room floor.

In many cases, these constant support hangers may either under-support or over-support the piping system, causing the whole system to sag or lift. Because of this, solid hangers are often used at points of zero vertical expansion movement to pick up any errors in support of the dead weight. Solid hangers are also used to protect the turbine from excessive forces and moments caused by the piping system.

Solid hanger rods, if not properly designed can produce reactions on the piping system many times greater than any reactions expected. It is, therefore, important that these hanger rods be properly located and be as long as possible, and that the pin or rocker joints work properly.

The connection of the condenser to the exhaust of a condensing turbine gives rise to some special problems.

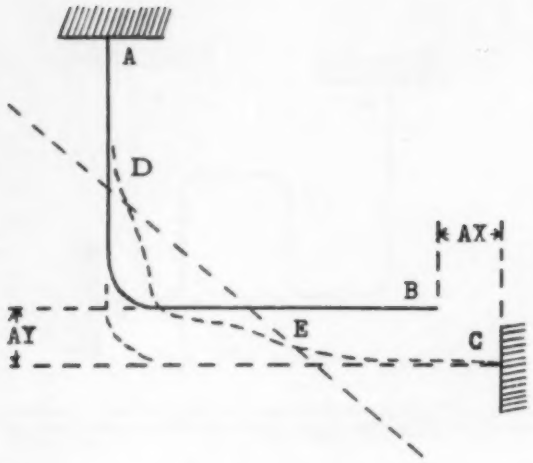


Fig. 5—"Cold springing" is one way of reducing or eliminating thermal stresses. The pipe is cut short, solid line, and then forced into final position, dotted line, while cold. Upon heating it would tend to assume this position and hence the stresses are less severe

Condenser Connection

The condenser may be solidly connected to the turbine exhaust or may be connected through an expansion joint.

When solidly connected, the weight of the condenser under all service conditions must be carried by the turbine. This arrangement has the advantage that changes in vacuum or pressure in the condenser do not change the suspended load on the turbine. However, the weight of the cooling water in the condenser and the weight of the water on the steam side during a leakage test also reacts back onto the turbine exhaust, and provision must be made to carry it. Spring supports may be used to partially reduce the load on the exhaust.

An expansion joint at the turbine exhaust has the advantage of freedom of movement vertically between the two and the elimination of the weight of the condenser and the water in it as a load on the exhaust flange. Some axial and lateral movement is possible but is limited. The disadvantage is the forces applied to the turbine by the vacuum load across the exhaust flange opening. The expansion joint may also be quite rigid in torsion and transmit moments to the turbine.

Attention must be given to the forces and moments on the condenser caused by piping connections to the condenser. For example, the circulating water pipes are often of large size and are connected to the condenser through expansion joints. The water pressure across the openings results in net forces and moments that must be considered in their effect on the turbine exhaust.

Allowance must also be made for the normal movement of the condenser from expansions either in the turbine or condenser shell.

Criteria for Limiting Forces and Moments

The allowable forces and moments acting on steam turbines, due to the high pressure, extraction, low-pressure admission, exhaust or other connections, should be limited to the following values:

A. Total Force and Moment Applied to Any Pipe

The total force and moment applied to any pipe should not produce a combined stress larger than the allowable fibre stress in the pipe as set forth in the applicable codes. The piping between the trip and throttle valve and the turbine should be included with the station piping in the flexibility calculations.

B. Non-condensing Turbines

1. The loading on the exhaust flange due to the piping connection is treated the same as the other piping connections to the turbine.

2. The vertical reaction at any given support due to the combined forces and moments of all piping connections or of any one piping connection should not exceed one-half the dead weight reaction of the turbine at the given support point. This applies to both upward and downward piping reactions. (The trip and throttle valve will be omitted in determining the dead weight reaction of the turbine.)

3. The horizontal transverse reaction at any support point due to the combined forces and moments of all piping connections or of any one piping connection should not exceed one-third the total dead weight reaction of the turbine at the given support point.

4. The axial force on the turbine due to the combined axial forces of all piping connections or the axial force of any one piping connection should not exceed one sixth of the turbine weight.

C. Condensing Turbines—Loading on Exhaust

1. The loading on the exhaust due to the condenser and piping connections to the condenser is treated as a separate item apart from the forces and moments due to all other piping connections to the turbine.

2. The maximum downward loading should not exceed 30 psi of exhaust area plus 10,000 lb.

3. The minimum downward loading should not be less than 3 psi of exhaust area or 10,000 lb, whichever is the smaller value.

4. The eccentricity of the downward loading with respect to the center of the exhaust opening should not exceed 12 in. in the sideways direction and 6 in. in the axial direction.

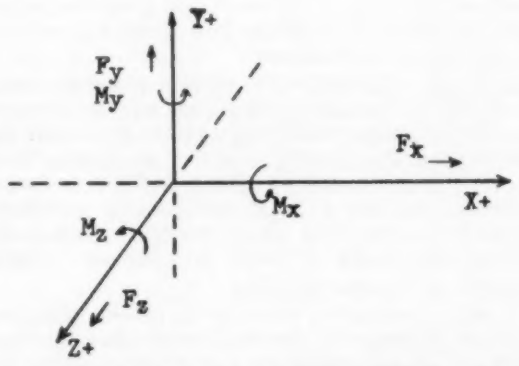


Fig. 6—In an effort to bring the stresses in turbine piping under field control the NEMA recommends that manufacturers provide diagrams such as above giving direction and allowable limits for combined forces and moments

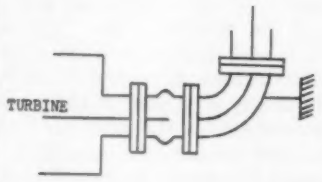


Fig. 7—Axial thrust from above expansion joint with anchored elbow connection is transferred to turbine and hence should be discouraged

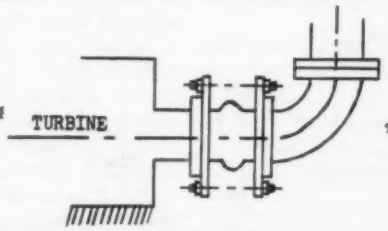


Fig. 8—Tie rods added to expansion joint of Fig. 7 limit joint elongation, take up axial thrust in the form of shear rather than tension

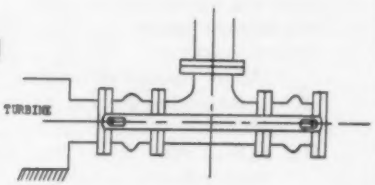


Fig. 9—Above tie rod connection prevents thrust from internal pressure being transmitted to the exhaust flange, retains joint axial flexibility

5. The maximum horizontal force on the exhaust flange in either the sideways direction or the axial direction should not exceed 1.5 psi of exhaust area or 5,000 lb, whichever is the lesser value.

6. The maximum moments in pound feet acting on the exhaust flange due to all effects except eccentricity of downward loading should not exceed:

(a) Moments about the axis of the machine—four times (exhaust area in square inches) plus 2000.

(b) Moments about the vertical axis at the centre of the exhaust—one-half the maximum moment about the axis of the machine.

(c) The moment about the transverse horizontal axis at the exhaust flange—equal to the moment about the vertical axis.

D. Condensing Turbine—Forces and Moments on High-Pressure and Extraction or Low-Pressure Admission Connections

1. The vertical reaction at either front support or at either exhaust support due to the combined forces and moments of all piping connections or of any one piping connection, (excluding the exhaust connection), should not exceed one-half the dead weight reaction of the turbine at the support point. This applies to both upward and downward piping reactions.

2. The horizontal, transverse reaction at the front supports due to the combined forces and moments of all piping connection or of any individual piping connection (excluding the exhaust connection) should not exceed one-tenth the total dead weight reaction of the turbine at the front standard.

3. The horizontal, transverse reaction at the exhaust hood supports due to the combined forces and moments of all piping connections or of any individual piping connection (excluding the exhaust connection) should not exceed one-tenth the total dead weight reaction of the turbine at the exhaust supports.

4. The axial force on the turbine casing due to the combined axial forces of all piping connections or the axial force of any one piping connection (excluding the exhaust connection) should not exceed one-sixth of the turbine weight.

The foregoing rules should cover most installations of standard turbines. Where unusual features are present either in the layout of the piping systems or in the construction of the turbine, a special analysis may be required and qualified assistance should be sought.

Limitations on Connections to Steam Turbines

The manufacturer should provide as a part of the installation data the following:

1. The location with respect to the machinery of the origin of the coordinate system to which allowable forces and moments are referred.

2. A diagram similar to Fig. 6 showing the direction of the positive forces and moments.

3. The allowable limits for the combined forces and moments of all piping connections or of any one piping connection acting on the turbine casing as follows:

F_x equal_____lb	M_x equal_____lb-ft
F_y equal_____lb	M_y equal_____lb-ft
F_z equal_____lb	M_z equal_____lb-ft

For non-condensing turbines the exhaust connection will be treated in the same as any connection above.

4. For condensing turbines, the exhaust loading is considered separately. The allowable exhaust flange loading due to the condenser and its pipe connections are as follows:

(a) Forces

I. Maximum downward_____lb

II. Minimum downward_____lb

III. Maximum horizontal_____lb

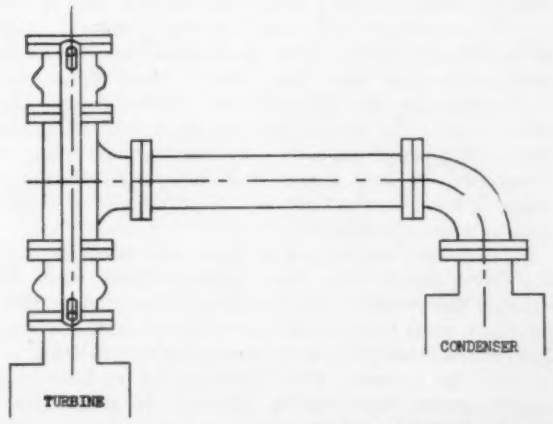


Fig. 10—Suggested arrangement for an up-exhaust. Tie rods provide necessary flexibility for thermal expansion and expansion joint is in shear

(b) Maximum eccentricity of the downward loading is 12 in. sideways and 6 in. axial

(c) Maximum moment due to other than downward load eccentricity:

I. About the axis of turbine_____lb-ft

II. About the vertical axis at center line of exhaust_____lb-ft

III. About the transverse horizontal axis at center line of exhaust_____lb-ft

5. The predicted maximum movement from cold to operating temperatures of all points on the turbine to which external piping is connected.

The allowable moments given in item 3 are total moments acting on the turbine casing and, as such, include the moment effect of the forces as well as the piping moments themselves. The total moments of the individual reactions on the casing can be arrived at by conventional methods for summing forces and moments.

The allowable forces and moments given by the manufacturer will be related to an origin shown on the drawings and a diagram of the direction of positive forces and moments, similar to Fig. 6. Purchasers may, of course, use any convenient coordinate system to calculate forces and moments. However, before final comparison with the allowable forces and moments, it will be necessary to transpose to the given coordinate system.

Mechanical-Drive Steam Turbines

The following information designed for mechanical-drive steam turbines is similar to the above material and is based upon the same principles. The main difference is that some short cuts have been applied for these mechanical drive units.

The stresses in such a piping system under operating conditions can be grouped into three classes; stresses due to steam pressure, stresses due to thermal expansion, and stresses due to dead weight.

Forces Due to Steam Pressure

These are most commonly associated with low pressure and vacuum lines where expansion joints are often used to provide flexibility. If an expansion joint is improperly used, it may cause a pipe reaction greater than the one which it is supposed to eliminate. An expansion joint will cause an axial thrust equal to the area of the largest corrugation times the internal pressure. The force necessary to compress or elongate an expansion joint can be quite large, and either of these forces may be greater than the limits for the exhaust flange. In order to have the lowest reaction, it is best to avoid absorbing pipeline expansion by axial compression or elongation. If it is found that expansion joints are required, it is essential that they be properly located and their function determined.

Fig. 7 shows an expansion joint in a pressure line. The axial thrust from the expansion joint tends to separate the turbine and the elbow. To prevent this, the elbow must have an anchor to keep it from moving. The turbine must also absorb this thrust and, in doing so, becomes an anchor. This force on the turbine case may be greater than can be allowed. In general, this method should be discouraged.

Fig. 8 shows the same piping arrangement as Fig. 7 except for the addition of tie rods on the expansion joint. The tie rods limit the elongation of the joint and take the axial thrust created by the internal pressure so it is not transmitted to the turbine flange. The tie rods eliminate any axial flexibility, but the joint is still flexible in shear, that is, the flanges may move in parallel planes. The location of this type of joint in the piping should be such that movement of the pipe puts the expansion joint in shear, not tension or compression.

Fig. 9 is an arrangement frequently used, having tie rods as indicated. This arrangement will prevent any thrust due to internal pressure from being transmitted to the exhaust flange and retains the axial flexibility of the joint. It applies for vacuum or pressure service.

Fig. 10 shows a suggested arrangement for a condensing turbine with an up exhaust. This arrangement is recommended and frequently used. Due to the large exhaust pipe size normally encountered on condensing turbines, the exhaust piping will be relatively stiff, and an expansion joint must be used at some point to take care of thermal expansion. An unrestricted expansion joint placed at the exhaust flange of the turbine will exert an upward or lifting force on the turbine flange which in many cases is excessive. Fig. 10 provides the necessary flexibility to take care of thermal expansion without imposing a lifting force on the turbine. The expansion joint is in shear which is the preferred use. The relatively small vertical expansion will compress one joint and elongate the other which causes a small reaction only and will be within turbine flange limits.

Effect of Temperature Expansions on Piping Systems

The same problems that were described under this same heading for Steam Turbine Generators appear in the application of piping to mechanical-drive turbines. The solutions are the same and we refer you to the appropriate heading above and Figs. 1–6.

Stresses Due to Dead Weight

The dead weight of the piping should be entirely supported by pipe hangers or supports. There are basically two types of supports, rigid and spring. Rigid supports are necessary when an unrestricted expansion joint is used. Rigid supports may be used to limit the movement of a line to prevent excessive deflection at any point. A rigid support is not satisfactory where thermal expansion may cause the pipe to move away from the support.

On the two types of rigid supports shown in Fig. 11, the rise of the turbine case due to temperature would lift the base elbow from the support so the turbine would have to support the weight of the pipe. The expansion of the vertical run of pipe would relieve the pipe hanger of its load so the turbine would again have to support the weight of the pipe.

If an expansion joint with restraining tie rods is used, either of rigid pipe hanger or a base elbow with a sliding or rolling contact surface may be used as shown in Fig. 12.

When the thrust due to an expansion joint is less than the exhaust flange limits and no restraining tie rods are used, the pipe must have an anchor as shown in Fig. 13. Since this condition rarely exists, it is better to use one of the better arrangements such as shown in Fig. 12 and eliminate as much pipe reaction as possible rather than just stay within the limits.

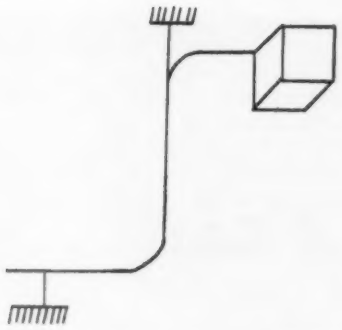


Fig. 11—Rigid supports such as above under temperature rise produce in the case of the elbow support a lifting action away from the support and onto the turbine. With the upper or pipe hanger support an expansion occurs in the vertical pipe moving it upwards and removing the hanger load which must be picked up by the turbine

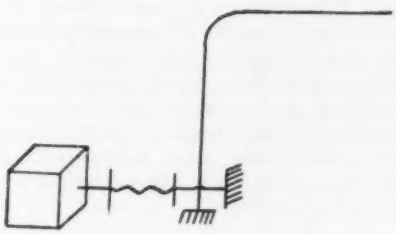


Fig. 13—When thrust due to an expansion joint is less than exhaust flange limit and there are no restraining tie rods the pipe must be anchored. The preferred method, however, is a piping arrangement such as Fig. 12 which eliminates all possible pipe reactions rather than just staying within limits as above

Spring hangers or supports are best suited to carry the dead weight when there is thermal expansion to be considered. The movement of the pipe will change the spring tension or compression a small amount and the hanger loading a small amount but will not remove the load from the hanger. The published manuals on pipe design provide information on hanger spacing to give proper support. In addition to this, it may be found necessary to add additional supports or move existing supports if resonant vibration appears in the piping.

A spring support should not be used to oppose the thrust of an expansion joint as, when the pressure is removed from the line, the spring support will exert a force the same as the expansion joint only in the opposite direction, producing problems of its own.

Allowable Forces and Moments

The forces and moments acting on mechanical-drive steam turbines due to the steam inlet, extraction and exhaust connections are limited by the following rules:

1. The total resultant force and total resultant moment imposed on the turbine at any connection must not exceed the following:

$$F = \frac{500\,D - M}{3}$$

F = Resultant force, (lb)—including pressure forces where unrestrained expansion joints are used at the connection except on vertical exhausts covered under (3)

M = Resultant moment (lb-ft)

D = Pipe size of the connection (ips) in inches up to 8 in. in diam. For sizes greater than this, use a value of D equal to $\frac{(16 + \text{ips}) \text{ in.}}{3}$

2. The combined resultants of the forces and moments of the inlet, extraction and exhaust connections, resolved at the centerlines of the exhaust connection must not exceed the following two conditions:

(a) These resultants must not exceed:

$$F_c = \frac{250\,D_c - M_c}{2}$$

F_c = Combined resultant of inlet, extraction and exhaust forces, lb

M_c = Combined resultant of inlet, extraction and exhaust moments and moments resulting from forces, lb-ft

D_c = Diameter (in inches) of a circular opening equal to the total areas of the inlet, extraction and exhaust openings up to a value of 9 in. in diam. For values beyond this, use a value of D_c equal to $\frac{(18 + \text{Equivalent Diameter})}{3}$

(b) The components of these resultants shall not exceed:

$F_y = 125\,D_c$ $\qquad$ $M_y = 125\,D_c$

$F_z = 100\,D_c$ $\qquad$ $M_z = 125\,D_c$

$F_x = 50\,D_c$ $\qquad$ $M_x = 250\,D_c$

F_y = Vertical component of F_c

F_z = Horizontal component of F_c at right angles of turbine shaft

F_x = Horizontal component of F_c parallel to turbine shaft

M_x = Component of M_c in a vertical plane at right angles to turbine shaft

M_y = Component of M_c in a horizontal plane

M_z = Component of M_c in a vertical plane parallel to the turbine shaft

3. For installation of turbines with a vertical exhaust

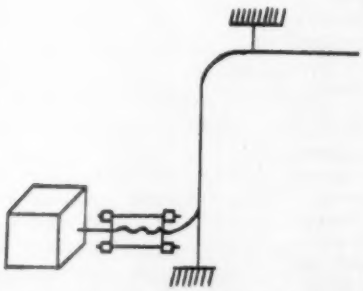


Fig. 12—An expansion joint with tie rods as shown in Figs. 8, 9 permits either a rigid pipe hanger or a base elbow with sliding or rolling contacts, as above

and an unrestrained expansion joint at the exhaust, an additional amount of force caused by pressure loading is allowed. (The additional force referred to is perpendicular to the face of the exhaust flange and central.)

For this type of application, calculate the vertical force component on the exhaust connection, excluding pressure loading, and compare with value of $^1/_6$ the pressure loading on the exhaust. Use the larger of these two numbers for vertical force component on exhaust connection in making calculations outlined in (1) and (2) of the material just presented.

The force caused by the pressure loading on the exhaust is allowed in addition to the values established by the above up to a maximum value of vertical force (lb) on the exhaust connection, (including pressure loading) of $15^1/_2$ times the exhaust area (sq in.).

4. These values of allowable force and moment pertain to the turbine structure only. They do not pertain to the forces and moments in the connecting piping, flange and flange bolting which should not exceed the allowable stress as defined by applicable codes and regulatory bodies.

Purdue University Establishes a Thermophysical Properties Research Center

PURDUE University, this winter, announced the establishment of a *Thermophysical Properties Research Center* with two long-range objectives: (1) To serve as a world center for research and for the collection, analysis, correlation and dissemination of data on thermophysical properties; (2) to provide unique facilities and opportunities for graduate study and research on thermophysical properties.

In this project, government agencies and industry are cooperating by providing multiple financial support. Each sponsor contributes approximately the amount of aid he might give an individual graduate student. At the same time, he is participating in and benefiting from a major research program covering a broad field of application. This method of financing enables the University to enter upon interdisciplinary programs which it might otherwise launch only with great difficulty.

The program is under the immediate direction of Dr. Y. S. Touloukian, professor of mechanical engineering. An advisory committee has been established to serve as a consulting body of experts and to act as a coordinating group for all research on thermophysical properties conducted at Purdue. Currently, Dr. Touloukian is forming a research staff consisting of trained and experienced personnel in physical chemistry, physics, metallurgy, chemical and mechanical engineering and library science. By the fall of this year the personnel will consist of ten full-time scientists and engineers constituting a nucleus assisted by graduate students doing research in this area.

During its first three years the program will be confined to seven essential thermophysical properties: thermal conductivity; viscosity; specific heat; thermal emissivity, absorptivity and reflectivity; mass diffusivity; thermal diffusivity; and Prandtl number. In terms of materials to be studied, the program will concern itself in a selective and gradual order with properties of gases, liquids and solids, starting with the technically more important materials and substances. Other criteria for selection of substances and properties to be studied will be: (1) demand for information on a given property, (2) paucity or abundance of available data and (3) degree of discord, if any, in a given area.

The staff literature searchers will enter the world literature in an attempt to locate all information on the seven properties listed above for all substances for which such information has been reported. Thus, the Research Center team will be in a position to undertake the study of any material and property without the necessity of repetitive literature searches each time.

All information amassed will be entered on IBM punched cards or tape in order to enable rapid scanning of large numbers of entries. Each entry will contain the author's name, title of the reference, source of the reference, the abstract number and source of abstract, and the classification codes for sorting by subject, substance and property. Upon request, the Research Center will be able to sort out all information on any one property or substance in a matter of minutes.

The analytical research phase of the program will consist of the following steps: (1) Taking one property and one material or a group of materials at a time, the researchers will critically evaluate, unscramble, reconcile and correlate all available data, coming up with an internally consistent set of tables which can be termed "most probable values" of the particular property and material as of a given date; (2) they will fill in gaps and extend available experimental data over higher or lower ranges of temperatures and pressures by means of semi-empirical or theoretical considerations whenever such procedures are justified; (3) they will generate tables of transport properties of gases and particularly of gas mixtures on the basis of statistical thermodynamics wherever experimental data on such properties are non-existent or nearly so; (4) they will prepare graphical representations of "most probable values" for each property, comparing recommended tabular values with all available experimental data; (5) they will review their work regularly since results of these studies will never be considered final, but will remain constantly subject to periodic revision and extension in the light of new information that may become available in the literature or from research being conducted by the staff of the Center.

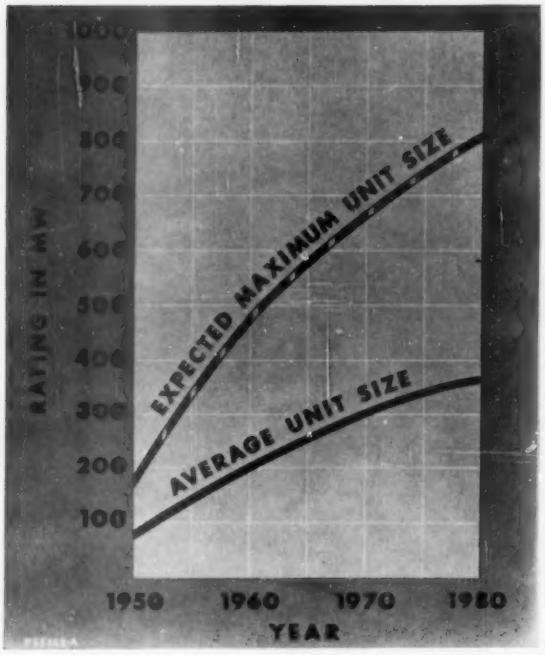


Fig. 1—Projecting the steam turbine size curve into the years ahead show 750 Mw units coming. The author points out that the size of the system purchasing these units has as much to do with size limitations as does the manufacturer's ability to build

The crystal ball always holds a strong appeal. The utility industry with its long write-off restrictions especially must be forward looking to anticipate trends and developments in the areas affecting its capital investment. Here is an educated guess on what the future promises in steam generation.

Projecting Steam Costs to 1980

By J. H. HARLOW*
Philadelphia Electric Co.

IN considering the nature of a steam electric power plant of 1980 burning fossil fuels, it is important to consider a number of items which have an important effect on the cost and performance of a conventional steam electric power station. Among these may be listed the following:

1. The size of the boiler-turbine-generator set.
2. The steam conditions such as temperature, pressure, number of reheats.
3. The choice of a plant cycle.
4. The efficiency of the combustion process.
5. The physical arrangement of the equipment.
6. Advances in the technology.
7. Changes in methods of preparing, conditioning or transporting fuel.

Equipment Size

About 1910 the horizontal steam turbine electric generator set became the standard device for the production of electricity. A very early set was a 5000 kw unit. Boilers of the same era were straight tube, box header designs, and it was quite common to install as many as ten or more boilers for each turbine.

Twenty years later turbine generator sets had attained capacities of over 100,000 kw. Such a set at that time might have received steam from three or four boilers.

Today there are several units of 300,000 kw or more being built, of which Philadelphia Electric's 325,000 kw supercritical pressure unit for Eddystone Plant is outstanding. And somewhat over a year ago the American Gas & Electric System announced the construction of

* Chief mechanical engineer.

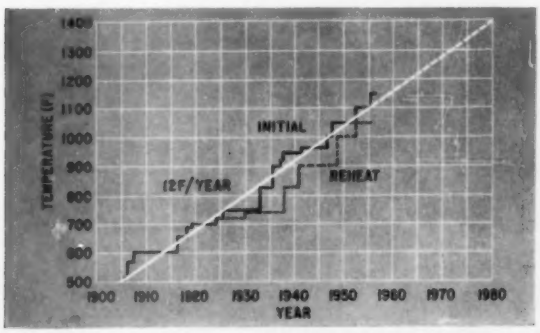


Fig. 2—Steam pressures pictured against the years are actual figures to 1956 and are then projected out to 1980

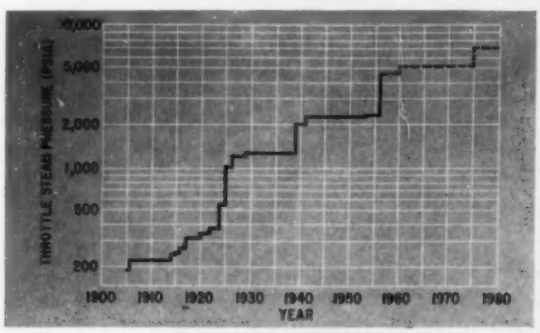


Fig. 3—Steam temperatures are actual to 1955 and projected thereafter. With Fig. 2 they show 7000 psi, 1400 F

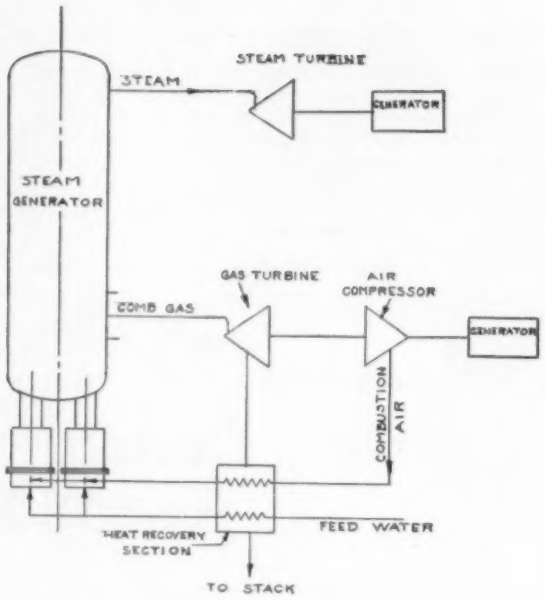


Fig. 4—Part of the improvements in overall heat rate will come from combined cycles such as the above with the gas turbine an integral part of the complete cycle

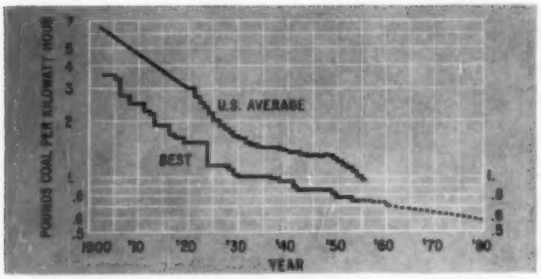


Fig. 5—The possible goal of a coal rate of 0.60 lb of 12,500 Btu coal with Figs. 2–4 seems in line with experience

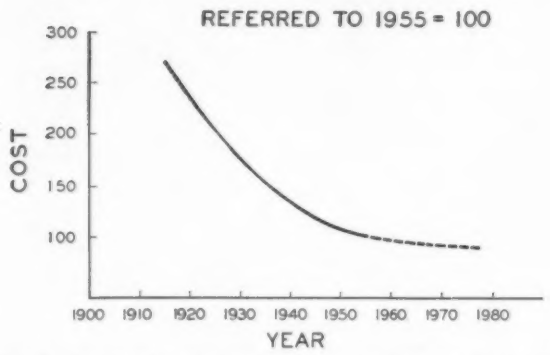


Fig. 6—Adjusted cost curves with constant value dollars referred to 1955 as 100 show the 1980 plant costing 90 per cent of the 1955 installation

two units of 450,000 kw size, each of which will be driven by a single boiler.

For 1980, it is quite reasonable to consider that single sets of 750,000 kw will be the order of the day. In fact, as shown by Fig. 1, this is a slowing down of the present rapid increase in sizes. The size of the unit is as much a function of the system in which it is to be installed as it is of the capacity of the manufacturers to build.

Steam Conditions

In regard to steam conditions, the best approach again would seem to be to take a good look at the past in order to obtain direction for the future much as a surveyor does when he is running a line. As shown by Fig. 2, steam temperatures have increased in the past in almost a straight line with an average slope of 12 degrees F a year. This is a fabulous accomplishment and surely must have an end somewhere. However, there appear to be metallurgical and other developments in the offing which seem to promise a continuation of this advance for a while longer. Therefore, we suggest that in 1980 the frontier of design will contemplate a main steam temperature of 1400 F. If it were not for problems of corrosion and erosion associated with the ash present in all solid and liquid fuels, this temperature would more surely be within reach by then. For this reason and others to be presently mentioned, we believe there will be a great deal of advance in the methods of conditioning the fuel. Ideally this would involve converting the solid fuel to gas with the removal of the ash, sulphur and corrosive salts. This could be done at the mines. Thus the fuel could be transported quite practically by pipe line and the useless harmful elements replaced and left in the pits from which they have come.

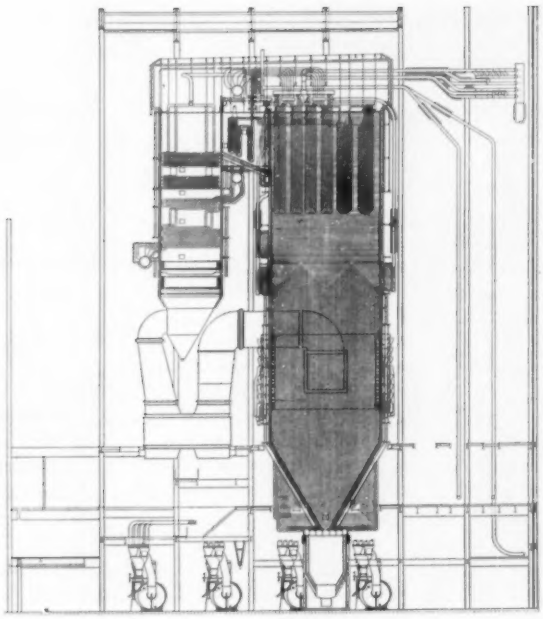
Advances in steam pressure have been associated with advances in steam temperature for thermodynamic reasons. In Fig. 3 the history of steam pressure is traced and extended to 7000 psi in 1980. This pressure is compatible with the predicted temperature of 1400 F.

Liquid Reheat

Higher initial temperatures and pressures give promise of more advanced reheat conditions. A method for reheating, not presently economical, is to use liquid metal to transport heat from the boiler to steam reheaters located adjacent to the turbine. This results in a simplification of piping and, with such a large unit as 750,000 kw, a possibility of economically developing three reheating stages at higher temperatures.

Combined Gas Turbine Cycles

There are now under study and development a number of improvements in cycle which will have marked effect on the performance of the plant of the future. One of the most exciting of these is an arrangement whereby the gas turbine can be incorporated in the steam electric power plant. In this arrangement, illustrated in Fig. 4, the gas turbine blower supplies air to a pressurized boiler furnace. Here the fuel is burned with an efficient amount of air and the furnace absorbs a portion of the heat so that the gases are cooled to a temperature suitable for the gas turbine. The gas is then expanded through the turbine and exhausted by way of additional boiler surface to the stack. Such a device will have two important advantages; one, the plant efficiency may be increased as much as five per cent, and two, the size of the furnace



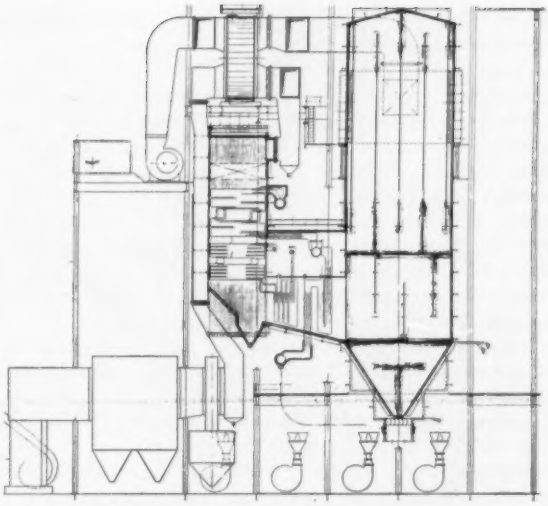


Fig. 8—Similar steam generator to that in Fig. 7 turned upside down locates superheater outlet nearer steam turbine and saves piping

Fig. 7—Present day arrangements with once-through steam generators for supercritical pressure operation have superheater outlet at top. See Fig. 8

will be substantially reduced. The accomplishment of this objective waits for one or the other of two obstacles to be overcome. Either it will be necessary to find a way to pass the products of coal burning through the gas turbine or the gasification scheme described earlier will be needed. By 1980 this should be solved.

Now, the end result of these developments will make it possible to build a steam electric plant with a calculated heat rate of about 7000 Btu per kwhr on the basis of 1.00 in. Hg back pressure at the condenser. Allowing for some actual performance margins and slippage in the scheduled advances, a coal rate of 0.60 lbs of 12,500 Btu coal can be expected in 1980. This not only seems to be reasonable but is also in line with past experience as shown by Fig. 5 which plots coal rates from 1900.

Future Costs

In the consideration of what might be expected regarding future plant costs, we have made a study of the historic costs of some plants familiar to us and have adjusted these costs by well recognized cost indices. The result has been the curve in Fig. 6, which shows costs of current plant designs of the past as related to the present and also a projection into the future. The costs are shown in constant value dollars referred to 1955 as 100. This curve would seem to indicate that the 1980 plant would cost about 90 per cent of the cost of the 1955 plant assuming, of course, that dollars are worth as much then as now. In view of the projected increase in size to 750,000 kw, this does not seem to be out of line.

As a matter of fact, two possibilities which might be considered at the present time for reducing costs can be

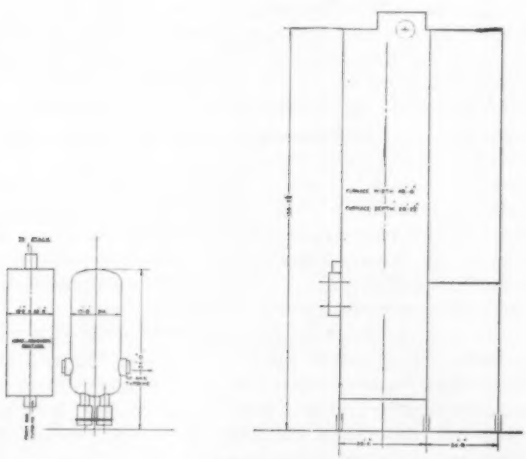


Fig. 9—In addition to piping economies, Fig. 8, pressurized boiler furnaces, probable by 1980, offer savings in building volume and supporting steel as evident in sample, left, against conventional unit, right, for a 200 Mw steam plant

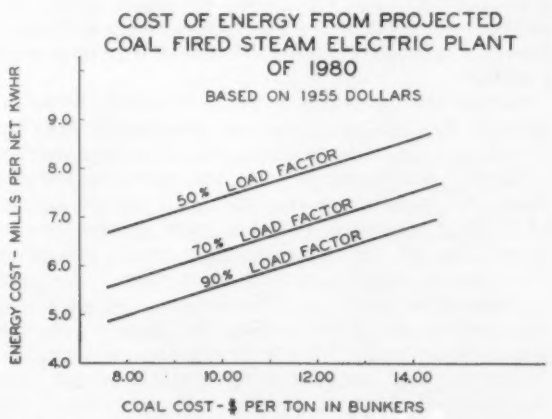


Fig. 10—The above set of energy cost curves for various coal prices and load factors used money costs including interest, amortization, taxes, at a rate of 12 per cent per year

illustrated. For example, the main steam pipe for advanced steam and temperatures must be made of expensive, exotic materials. In order to reduce the quantity of this material a study illustrated by Figs. 7 and 8 has been made to show how, by turning the boiler upside down, the superheater outlet could be located close to the turbine. The saving is obvious. As another example, probably further in the future but which could be expected by 1980, is illustrated by Fig. 9. This shows the effect of pressuring the boiler furnace as would be accomplished by using the gas turbine cycle referred to earlier. The saving in building volume and in supporting steel is apparent.

The reduction of 10 per cent in plant costs could be substantially enlarged on the basis of gaseous fuel made from coal at the mines. In such a situation coal handling and storing facilities, pulverizers, ash hoppers and transporting equipment, all stack gas cleaning equipment and the supporting building could be eliminated. These items cost in the order of 15 per cent of the total plant cost. In the case of a 750,000 kw unit this would represent from 10 to 15 million dollars.

Conclusion

In summary, therefore, the probable contemporary advanced design of a fossil fuel burning steam electric power plant of 1980 will be as follows:

Unit Size—750,000 kw
Steam Temperature—1400 F
Steam Pressure—7000 psi
Three stages of reheat by liquid metal heating to 1300 F, 1250 F and 1250 F respectively
Gas turbine in the cycle
Coal rate 0.60 lbs per net kwhr
Cost $150 per kw with solid fuel (1955 dollars)
$135 per kw with gaseous fuel (1955 dollars)

In such a plant costs per kwhr for various coal prices and load factors would be as shown in Fig. 10. In computing this data money costs including interest, amortization, taxes, etc. are assumed to be at the rate of twelve per cent per year.

The Proposed Atomic Energy Indemnity Bills

The Joint Committee on Atomic Energy, meeting in executive session the early part of May, voted to report out of the Committee the proposed atomic energy indemnity legislation, together with certain new features, and to recommend to the Congress that it pass the bill. The Committee report to accompany the new bill is now in the final stages of preparation and when it is ready, both the report and the bill will be introduced together. However, while this report is not yet available, Senator Clinton P. Anderson, before the American Management Assn. felt it entirely proper to reveal its probable contents and offer a description of some of its features.

In general, the first four sections of this year's bill are very similar to S. 4112, 84th Congress, 2d Session, which was last year's bill. After amending section 2 and section 53 (e) (8), and adding some definitions to the Act, section 4 of the bill adds a new section 170 to the Atomic Energy Act entitled "Indemnification and Limitation of Liability."

Section 170 (a) provides that each reactor license issued by the AEC shall have a requirement that the licensee have and maintain adequate financial protection.

Section 170 (b) provides that the amount of financial protection required by the AEC shall be the amount of liability insurance available from private sources, except that the AEC may establish a lesser amount on the basis of criteria set forth in writing.

Then, subsection c. provides that the AEC shall agree to indemnify and hold harmless the licensee and other persons from public liability arising from a nuclear incident which is in excess of the level of financial protection required of the licensee. The maximum Government indemnity for each nuclear incident shall not exceed $500 million.

By subsection d., in addition to licensees, the Commission can also enter into contracts of indemnification with its contractors for construction or operation.

Subsection e. provides for limitation of liability and apportionment of claims in the very remote event that the total liability might exceed the amount of financial protection obtained by the licensee plus the $500 million Government indemnity.

Subsection f. authorizes the Commission to collect a fee for its $500 million indemnity which is based on a very low rate of charge, and is not intended to build up a fund, but only to compensate the Government for its paper work and administrative work load.

Subsection g. provides that in administering its provisions, the AEC shall use, to the maximum extent practicable, the facilities and services of private insurance organizations, and the AEC may contract to pay a reasonable compensation for such services.

Subsection h. allows the AEC to make certain arrangements in handling claims and subsection i. provides for a survey and report after an incident.

As for sections 5, 6 and 7, the bill provides that there shall be established a Committee on Reactor Safeguards which shall review applications for certain reactors and issue public reports thereon, and also that there shall be public hearings on certain reactor license applications. These three sections are new to this year's bill.

The first significant change appears in connection with the definition of public liability, which of course determines the situations under which the Government indemnity would come into play. As compared with last year's bill, this year's bill adds the words, "except for claims arising out of an act of war."

The definition of "public liability" has also been drafted in an attempt to provide indemnity for damage to "off-site" property of the reactor operator.

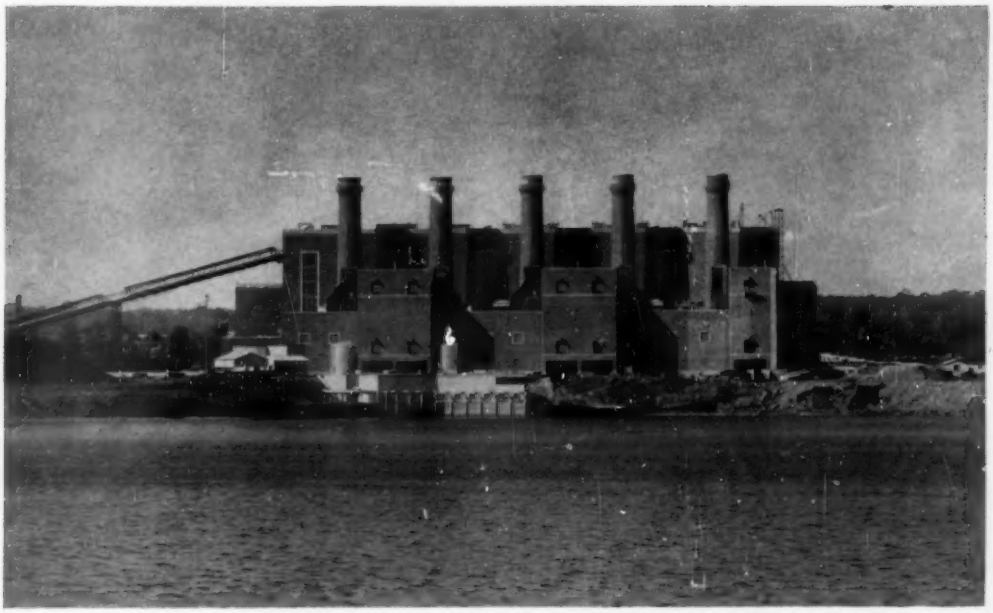


Fig. 1—Potomac Electric's Generating Station, located at the northern limits of the city of Alexandria, Va., is designed to harmonize with architecture of surrounding community. Ash storage silos and unloading equipment are housed within building to improve outside appearance

A Case History of Automatic Ash and Dust Handling Progress

By B. C. Berry*

Allen-Sherman-Hoff Co.

Mechanical removal of power plant dust and ash has been well accepted by industry for the advantages it gives in labor-saving and plant and neighborhood cleanliness. This case history report gives the details on a system designed to extend these advantages into the maintenance field. The major components are sized and interconnected to permit flexibility in service and in scheduling outages.

THE Potomac River Generating Station, Alexandria, Va., Fig. 1, is located adjacent to a highly developed residential area. Because of its location the Potomac Electric Power Co. has taken every possible precaution against smoke and coal dust nuisances. These precautions cover each step from the initial handling of coal to the final disposal of bottom ash and flyash.

Coal Handling

Coal reaches the Potomac River Station by rail and is unloaded by a rotary car dumper[1] totally enclosed and equipped with a dust collecting system to permit dustless unloading of these coal cars. The Bradford breaker house, next in the coal's path to the boiler furnaces, the coal bunkers in the station, and all intermediate coal-conveyor transfer points are all served by dust collecting systems. The surface of the 150,000-ton coal-storage pile is sprayed periodically with heavy fuel oil to prevent dusting.

The Ash Problem

This coal serves as the fuel supply for five Combustion Engineering, Inc. steam-generating units with a total steaming capacity of 3,775,000 lb per hr supplying five turbine-generator units. All five boilers employ complete pneumatic ash and dust-handling equipment designed by Allen-Sherman-Hoff Co. The last three boilers, however, carry equipment that represents the latest design trends in pneumatic handling devices and hence it will be this equipment that we will describe.

The station's facilities for ash and dust handling include mechanical flyash collectors and electrostatic

---

* Chairman of the Board.

[1] Design Features, Operating Experience and Performance of a 100,000-Kw Reheat Installation at Potomac River Station, L. W. Cadwallader and H. S. Frederick, COMBUSTION, May 1955, pp. 38–43.

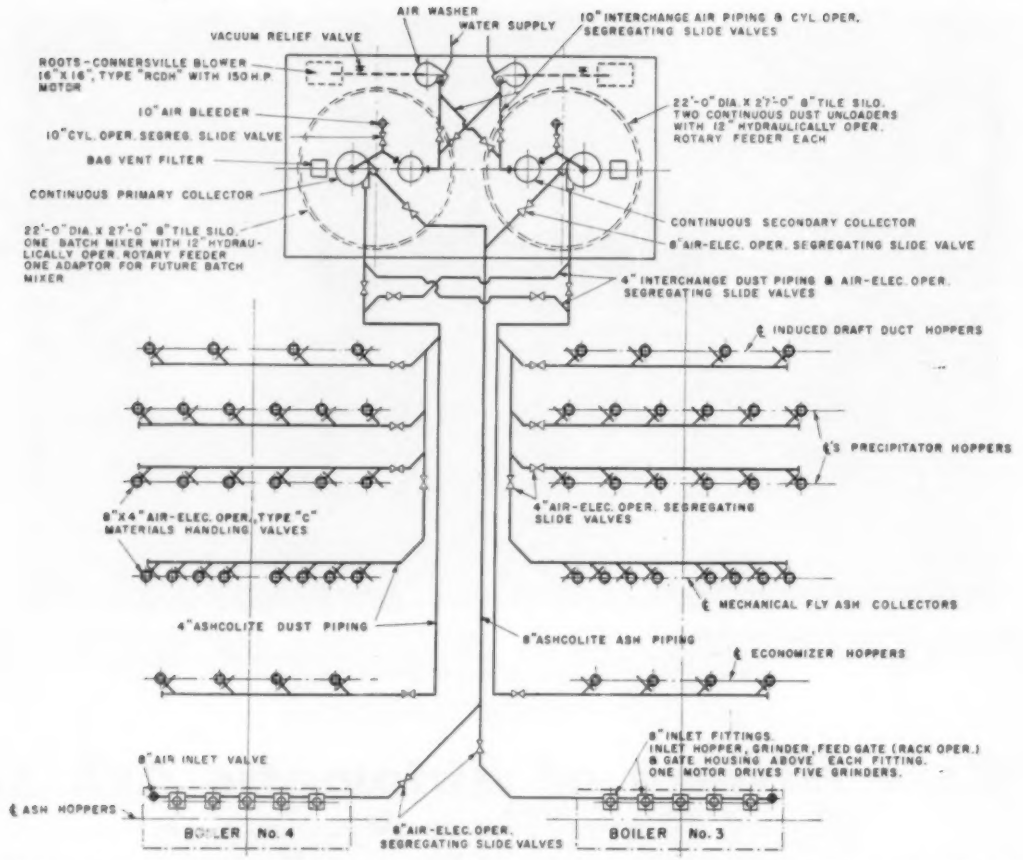

AIR WASHER
WATER SUPPLY
10" INTERCHANGE AIR PIPING & CYL OPER. SEGREGATING SLIDE VALVES
VACUUM RELIEF VALVE
ROOTS-CONNERSVILLE BLOWER 16" X 16", TYPE "RCDH" WITH 150 H.P. MOTOR
10" AIR BLEEDER
10" CYL. OPER. SEGREG. SLIDE VALVE
BAG VENT FILTER
CONTINUOUS PRIMARY COLLECTOR
22'-0" DIA. X 27'-0" 8" TILE SILO. ONE BATCH MIXER WITH 12" HYDRAULICALLY OPER. ROTARY FEEDER ONE ADAPTOR FOR FUTURE BATCH MIXER
22'-0" DIA. X 27'-0" 8" TILE SILO. TWO CONTINUOUS DUST UNLOADERS WITH 12" HYDRAULICALLY OPER. ROTARY FEEDER EACH
CONTINUOUS SECONDARY COLLECTOR
8" AIR-ELEC. OPER. SEGREGATING SLIDE VALVE
4" INTERCHANGE DUST PIPING & AIR-ELEC. OPER. SEGREGATING SLIDE VALVES
℄ INDUCED DRAFT DUCT HOPPERS
℄'S PRECIPITATOR HOPPERS
8"X4" AIR-ELEC. OPER., TYPE "C" MATERIALS HANDLING VALVES
4" AIR-ELEC. OPER. SEGREGATING SLIDE VALVES
℄ MECHANICAL FLY ASH COLLECTORS
4" ASHCOLITE DUST PIPING
8" ASHCOLITE ASH PIPING
℄ ECONOMIZER HOPPERS
8" INLET FITTINGS. INLET HOPPER, GRINDER, FEED GATE (RACK OPER.) & GATE HOUSING ABOVE EACH FITTING. ONE MOTOR DRIVES FIVE GRINDERS.
8" AIR INLET VALVE
℄ ASH HOPPERS
BOILER No. 4
8" AIR-ELEC. OPER. SEGREGATING SLIDE VALVES
BOILER No. 3

Fig. 2—Schematic diagram showing paired arrangement of pneumatic ash and dust handling system used on boilers

precipitators[2] which insure removal of over 99 per cent of the suspended matter in the stacks. This results in large quantities of flyash which must be transported, stored and disposed of with maximum efficiency, cleanliness and dependability. The method employed at Potomac River ties the collection units for the flyash in with those from the economizer and induced draft dust hoppers, Fig. 2. All operate under completely automatic sequence control.

Following modern practice in power plant design, Potomac Electric provided a separate removal system for each boiler unit with cross-connections in the piping and equipment between each pair of units. This gives maximum flexibility and utility in operation because flyash or bottom ash from one unit can be directed into the collecting and storage facilities for the other unit—either unit's vacuum producer being usable on one or the other units. Where flyash represents more than 20 per cent of the total ash fully pneumatic systems perform excellently.

The paired arrangement of the handling systems used on Boilers 3 and 4 (newest design) is shown schematically in Fig. 2. This diagram shows locations and general descriptions of the equipment for handling both flyash and bottom ash from the boiler furnace proper. The air-electric operated valves, shown schematically, are remotely controlled from a panelboard, as described later in this article.

The two sets of collectors, Fig. 2, consisting of primary and secondary stages with their associated storage and disposal equipment, serve both the dust and bottom ash handling transport lines. Handling air for both services is provided by mechanical vacuum pumps.

Transport piping conveys the dust and bottom ash a maximum distance of 275 feet, including 91 feet of lift to the collectors. This class of service requires a special piping and in this instance both the 4-in. dust lines and the 8-in. bottom ash lines are constructed of abrasion-resistant Ashcolite pipe and fittings, connected by sleeve type couplings. Fig. 3 shows a typical portion of the dust handling line.

In subsequent sections of this article, the system descriptions are grouped as follows: (1) flyash removal; (2) bottom ash removal; (3) ash collecting; (4) ash storage and disposal; (5) automatic and manual controls.

Flyash Removal

Flyash accumulates in hoppers arranged in groups at several locations, shown in Fig. 4. Individual dust valves feed this ash from one hopper at a time into the branch lines which join groups of hoppers to the main dust transport line for each boiler. A segregating slide valve in each branch line confines the vacuum to the operating zone. This insures the highest possible

[2] Series Dust Collector Installations on Large Pulverized Coal Boilers, L. W. Cadwallader, COMBUSTION, August 1952, pp. 47-49.

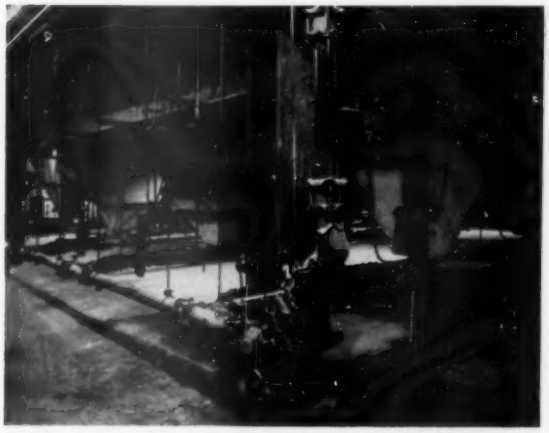


Fig. 3—Abrasion-resistant Ashcolite pipe and fittings with sleeve-type couplings carry dust from hoppers to collectors. Note 45-degree angle elbow fittings in foreground; this design is used throughout piping to minimize wear at bends

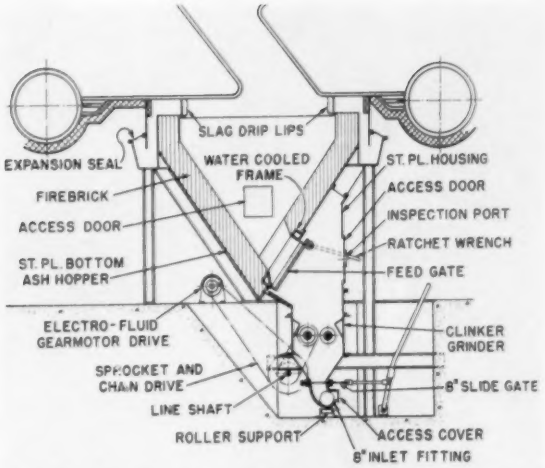


Fig. 4—Section view through bottom ash hopper at the ash discharge opening

vacuum and therefore highest handling rates in the portion of the system conveying flyash.

Dust transport lines from either boiler unit can be diverted to either collector system. From a remote panel board, the operator manually controls four 4-in. segregating slide valves, air-electric operated, on interchange piping near the collectors, as shown in Fig. 4.

Bottom Ash Handling

Since pneumatic systems can only utilize dry hoppers the entire load of preparing the ash for transport falls on a sizing grid or a grinder. In general a grinder is necessary in all large systems where the ash is not both granular and friable. The diagram of Fig. 4 shows the details of the bottom ash hoppers with their clinker grinders and also the connection to the 8-in. transport piping. One of these units is installed beneath each of the five discharge openings on the three newer boilers, Fig. 6. Branch lines connect each group of five units to a common 8-in. Ashcolite main transport line which leads to the collectors (See Fig. 3). Segregating slide valves, both at the boilers and at the collectors, permit separate operation of the removal system for each boiler with either collector system.

The ash hoppers are constructed from welded plate with firebrick lining. Sloped sides on the hoppers facilitate gravity feeding of ash through the discharge openings. Counterweighted feed gates, operated by ratchet wrenches, are used to close these openings. A refractory lining and water-cooled frame protects each gate against damage due to heat. In the two end walls of each hopper, 17-in. by 17-in. refractory-lined doors with 6-in. inspection ports provide access to the hopper.

A steel plate housing encloses each feed gate and intake point on the branch transport line. Double-roll clinker grinders size and feed the ash into the inlet fittings. A 5-hp electro-fluid gear motor drive on a line shaft gang drives the five grinders on each boiler.

At each inlet fitting a lever-operated slide gate permits flow to the transport line (See Fig. 4). Air for the bottom ash transport piping enters the end of the line through a spring-loaded air inlet valve.

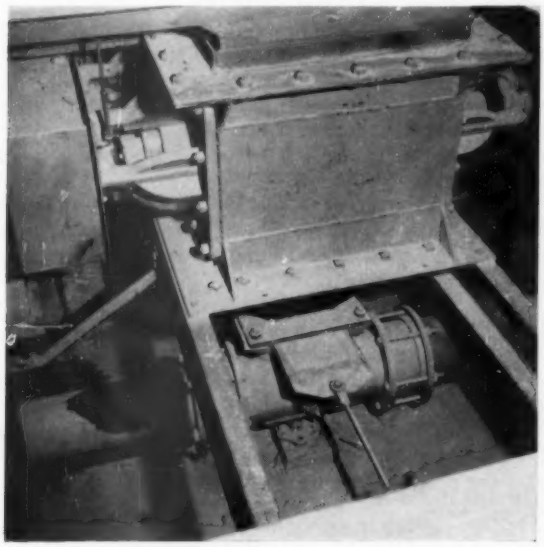
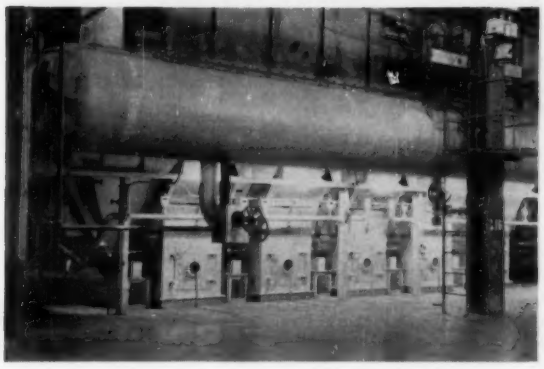


Fig. 6—Above the inlet fitting on the branch line is an 8-in. slide gate which closes the intake opening when not feeding ash into the transport pipeline. See left.

Fig. 5—Bottom ash hopper on boiler No. 3, showing feed gate housings through which ash is discharged to double-roll clinker grinders and transport pipeline below floor level. (See below).



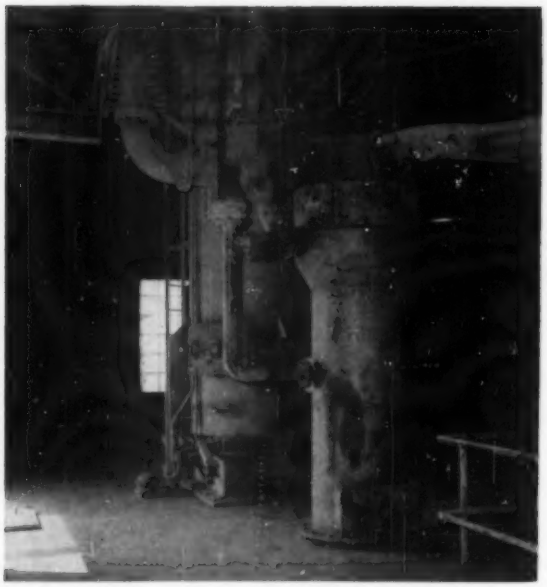


Fig. 7—Continuous ash collectors on boiler No. 3—primary unit in background and smaller secondary unit in foreground.

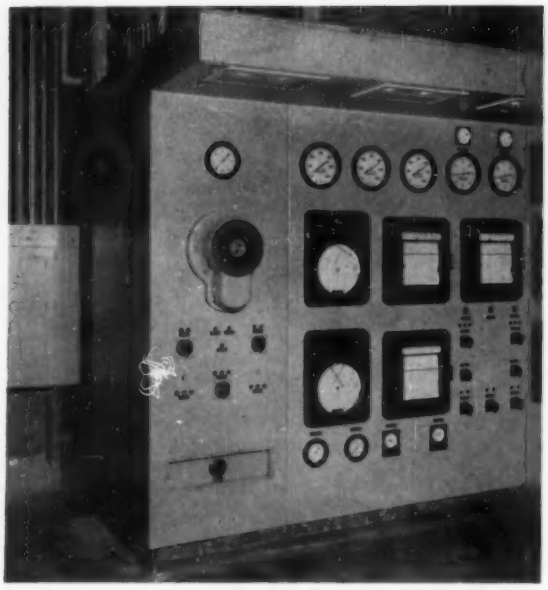


Fig. 9—The automatic sequence control switch and accessory equipment are at one end of the centralized control panel for each unit

Ash Collecting System

To collect both flyash and bottom ash, Potomac Electric selected the new A-S-H continuous, two-cell collectors. Fig. 2 shows the piping and auxiliary equipment for the collectors and Fig. 7 shows the units. These permit dumping without interrupting the collecting operation.

Individual Roots-Connersville blowers provide the operating vacuum for the two collector systems. They draw the conveying air from the collectors through 10-in. diam steel piping, and discharge through a muffler, into the breeching. A vacuum relief valve limits the vacuum to prevent possible collapse of the blower casing.

There is some possibility of fine ash particles remaining entrained in the air stream after it has passed through both primary and secondary collectors. Air washers in the suction piping between collectors and blowers remove any such carryover from the collectors. As shown in Fig. 2, cross-connections between the blowers permit use of either blower with either collector unit. Four 10-in. segregating slide valves control the flow in these lines. A 10-in. air bleeder valve provides makeup air when the system draws flyash through the smaller 4-in. transport line. This provides uniform air flow through the tubular type secondary collector, thereby maintaining collection efficiency.

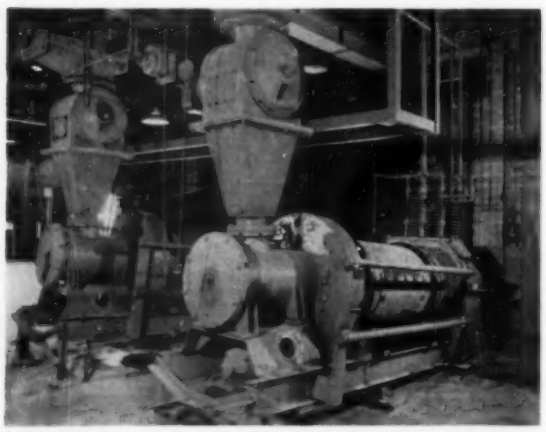


Fig. 8—A pair of rotary mixers and unloaders serves one storage silo. Chainwheel-operated slide gate admits ash to rotary feeder which regulates flow of ash to the unloading equipment

Ash Storage and Disposal

The ash collectors on each unit discharge into 7500 cu ft storage silos constructed of vitrified tile. Each silo vents to atmosphere through a bag filter. Accumulated ash flows by gravity from the silo through the unloading equipment which conditions the ash to eliminate dust nuisance.

Two types of unloading equipment are installed at Potomac Electric. One type, the rotary mixer and unloader, Fig. 8, handles both bottom ash and flyash. The other type, a batch type dust conditioner, handles only flyash. With each pair of boiler units, two rotary mixers serve one silo while the batch type conditioner serves the other silo.

A 12-in. diam slide gate (chain-wheel operated) opens or closes the silo discharge line to the unloading equipment. The gate is specially designed to eliminate jamming and plugging with ash.

A rotary feeder above each unloader regulates the ash flow. Driven by a high-pressure hydraulic unit, the rotor reverses automatically to clear the feeder when it encounters oversize particles. This design protects the feeder from mechanical damage.

The rotary mixer and unloader moistens and loads the ash into trucks for dust-free removal. The operator regulates the proportions of ash and water to obtain a suitable mixture.

The batch type dust conditioner automatically propor-

tions the amounts of flyash and water, mixing them to the proper consistency before discharging to the truck. It mixes and loads one batch at a time—the number of batches being calculated to just fill a truck.

Automatic and Manual Controls

A centralized control panel for each boiler unit includes automatic and manual units for operation of the ash removal systems (See Fig. 9). Electrical interlocks on each panel permit the operator to direct either the flyash or bottom ash from a boiler unit to either collector group. The interlock prevents the improper selection of equipment.

The flyash removal system normally operates on automatic control. An automatic control switch sequences the operation of the valves on the various hoppers. The operator can follow the progress of the operation by observing the indicating dial light on the control switch and the vacuum gage above the switch. At the conclusion of the removal cycle, the sequence control returns to the starting position, automatically de-energizing the ash handling controls and shutting the system down.

A control switch on each panel permits the operator to select either "automatic" or "manual" operation. When using manual control, the operator "jogs" this switch to proceed from hopper to hopper, being guided by the vacuum gage reading.

The operator activates the bottom ash removal system from a separate control switch on the panel. He then goes to the hopper to be cleaned, energizes the clinker grinder, and opens the lever-operated slide gate at one intake point. He next opens the feed gate to admit ash to the transport line. The operator repeats this procedure at each intake point emptying each hopper in turn. He then de-energizes the system from the control panel.

Properties of Cast Iron at Elevated Temperatures—A Progress Report

By J. R. KATTUS*

Since 1954 a research project to investigate the "Properties of Cast Iron at Elevated Temperatures" has been in progress at Southern Research Institute under the sponsorship of the ASME-ASTM Joint Committee on Effects of Temperature on Properties of Metals. The objective of this work is to determine the suitability of cast-iron alloys for load-carrying applications in the temperature range 700 F to 1000 F.

The following phases of work have been completed:

1. A literature survey of related work in this field.
2. Screening tests on twelve commercial cast-iron alloys.
3. Creep-rupture tests at 800 F and 1000 F on seven of the most promising alloys for times up to 5000 hours.
4. Thermal-shock tests on the same seven alloys.

As a result of the literature survey and screening tests, the following seven plain and low-alloy cast irons were selected for creep-rupture tests and thermal-shock tests:

1. Molybdenum-alloyed, pearlitic gray iron.
2. Nickel-molybdenum-alloyed, pearlitic gray iron.
3. Chromium-alloyed gray iron with a matrix of 50 per cent pearlite and 50 per cent ferrite. This iron was annealed 4 hours at 1650 F.
4. Unalloyed, ferritic nodular iron.
5. Chrome-nickel-moly-vanadium-alloyed, pearlitic gray iron.
6. Unalloyed, pearlitic gray iron.
7. Chrome-moly-alloyed, pearlitic gray iron.

The creep-rupture properties of the tested cast-iron alloys are not promising for applications requiring the support of appreciable loads for long periods of time at 1000 F. The alloys with high short-time creep-rupture properties at 1000 F underwent a sharp decrease in properties with exposure times of approximately 100 to 500 hours. The alloys that did not experience this sharp decrease had uniformly low creep-rupture properties.

The test results indicate that cast-iron alloys are suitable for load-carrying applications at 800 F. At this temperature, no sharp deterioration in creep-rupture properties occurred in exposure times of 5000 hours.

Alloying has a marked effect on the creep-rupture properties of cast iron. Among the alloying elements tested, molybdenum is the most potent for improving these properties. The chrome-moly iron had the best properties of all the alloys tested, but chromium additions alone were not beneficial to creep-rupture properties. The chrome-moly iron had creep-rupture properties intermediate to those of a hot-rolled carbon-moly steel and a hot-rolled low-carbon steel. All of the other irons were inferior in creep-rupture properties to the low-carbon steel, although the chrome-nickel-moly-vanadium iron approached it closely. The unalloyed ferritic nodular iron was slightly superior to the unalloyed pearlitic gray iron.

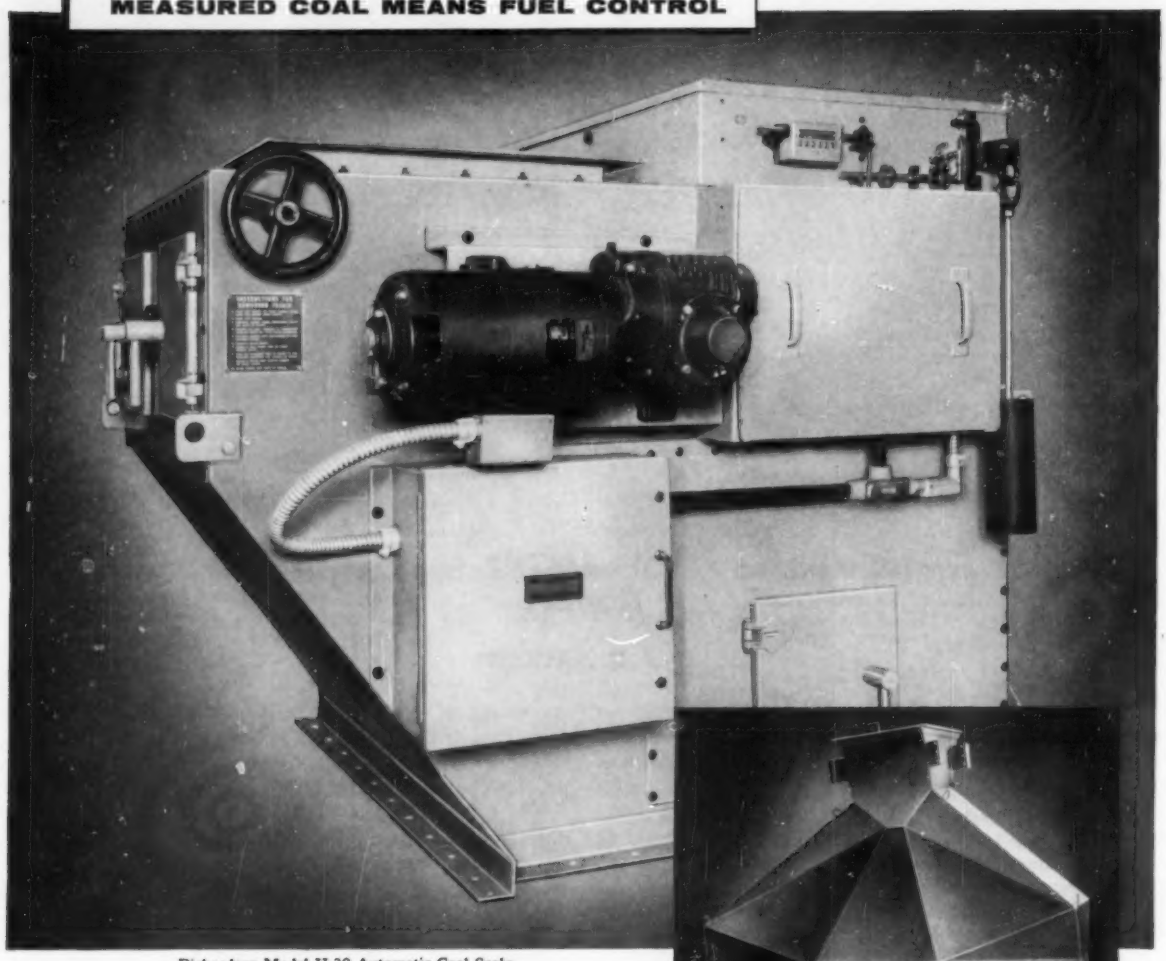
In the following table, the 10-year rupture strength and thermal-fatigue endurance limit for various alloys at 800 F are compared:

Alloy	10-Year Rupture Strength at 800 F, psi	Thermal-Fatigue Endurance Limit in Tension at 800 F, psi
Chrome-moly gray iron	30,000	17,500
Molybdenum gray iron	25,000	15,000
Chrome-nickel-moly-vanadium gray iron	25,000	16,000
Unalloyed ferritic nodular iron	17,000	27,500
Unalloyed gray iron	15,000	12,500
Nickel-moly gray iron	25,000	18,000
Chromium gray iron	...	12,500

Necessarily, the 10-year rupture strength is based upon an extrapolation of the test data and also upon an approximation afforded by the Larson-Miller Parameters.

* Head, Metallurgy Section, Southern Research Institute.

MEASURED COAL MEANS FUEL CONTROL



Richardson Model H-39 Automatic Coal Scale

Exclusive Richardson "Monorate," an important accessory, distributes all coal evenly across stoker.

Automatic fuel control with a Richardson H-39

All Richardson H-39 coal scales feature a LARGE 24" x 24" inlet. Coal moves through freely from bunker to stoker or pulverizer, never "arches" in an H-39 feeder or weighing hopper.

Richardson Coal Scales assure top performance, low maintenance, low operating cost, and trouble-free operation under all boiler-room conditions. They provide a continuous, accurate record of fuel consumption.

All contact platework of stainless steel. Quick, easy access to all parts of scale —all positively dust-sealed. All electrical equipment totally enclosed and installed *outside* of dustproof housing —never in contact with coal dust at any time. Endless belts available. Feeder is removable for maintenance. This scale includes *everything* dictated by 40 years of experience in automatic coal weighing.

For stoker fired boilers, the Richardson Monorate Distributor maintains uniform delivery of coarse and fine coal. No internal baffles. Designed for your conditions.

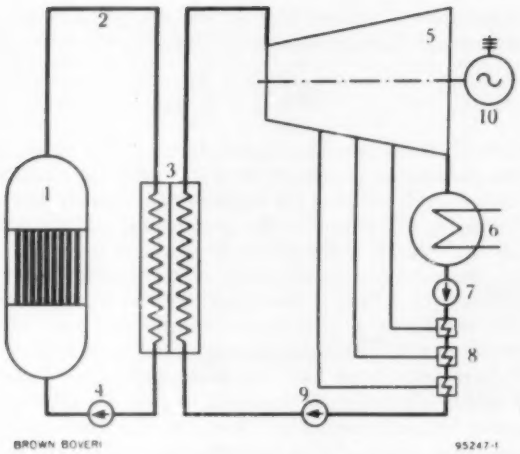
A nation-wide service organization of Richardson specialists guarantees accurate performance of all Richardson installations. Write today for Bulletin No. 0352A and 1349 for complete information.

Richardson
MATERIALS HANDLING BY WEIGHT SINCE 1902

4608

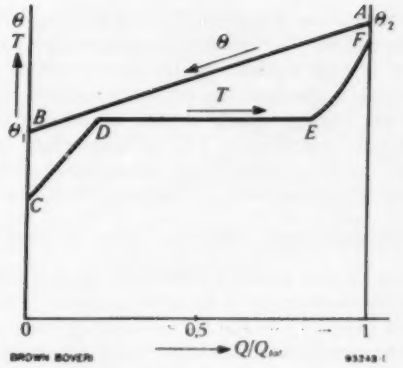
RICHARDSON SCALE COMPANY, CLIFTON, NEW JERSEY

Atlanta • Boston • Buffalo • Chicago • Cincinnati • Detroit • Houston • Memphis • Minneapolis
New York • Omaha • Philadelphia • Pittsburgh • San Francisco • Wichita • Montreal
Toronto • Havana • Mexico City • San Juan • Geneva, Switzerland • Nottingham, England



1 = Reactor
2 = Heat-carrier circuit
3 = Heat exchanger
4 = Pump circulating carrier
5 = Turbine
6 = Condenser
7 = Condensate pump
8 = Feed-water heater
9 = Feed pump
10 = Alternator

Fig. 1. — Atomic power plant with reactor heat utilized by a steam turbine



T = Temperature of working medium
ϑ = Temperature of heat carrier
Q = Successively applied heat
Q_{tot} = Total applied heat
A = Carrier inlet
B = Carrier outlet
C = Feed-water inlet
D = Evaporation starts
E = Evaporation stops
F = Steam outlet

Fig. 2. — Temperature diagram of the heat exchanger

Thermal Problems of Atomic Power Stations—II*

In this sequel to a previous article the authors investigate the conditions for the most favorable steam- or gas-turbine cycle when the upper and lower temperature limits of the reactor coolant are given. The efficiencies of such cycles are given by curves. At low temperatures only a steam turbine can be considered, whereas at higher temperatures either steam or gas turbines may be suitable, depending upon the output and local conditions.

By C. E. LUNDGREN and C. SEIPPEL

Brown Boveri and Co., Ltd.

THIS article is intended to cover a particular section of the theory of thermal machines, that is, the investigation of how the heat contained in a carrier can be converted most economically into mechanical or electrical energy. The carrier, a gas or liquid, flows through a source of heat—in this case a nuclear reactor is primarily considered, although the remarks are equally applicable to waste heat from any source or the product of any other heat generator—and in doing so is heated to the temperature, θ_2. Heat is extracted when the carrier is cooled to θ_1, at which it either returns to pick up more heat or is allowed to flow away. Let us assume that in the range $\theta_1 \leq \theta \leq \theta_2$ the specific heat of the carrier can be considered constant with reasonable accuracy, thus eliminating the possibility of any change of state, such as condensation of a vapor. Let us also assume, to begin with, that the heat carrier is not considered for propulsion and must therefore first transfer its heat to the working medium.

Various systems are available for the solution of this problem: first and foremost, steam generators with steam turbines, or alternatively, gas heaters with gas turbines. What shall be the characteristics of these machines? In the boiler, shall the heat carrier be passed through a nest of tubes in an evaporating drum to produce saturated steam, or is it worth while transferring the heat by counterflow, thus preheating the feedwater at the coldest point in the exchanger and superheating as much as possible at the hottest point? Shall the feedwater be preheated by bled steam, and if so, to what extent? Shall steam be fed into the turbine at two or even more pressures? Shall the gas turbine be of the closed- or open-cycle variety? Shall it have a preheater, and if so, for what temperature range? Shall the gas be cooled between compression stages or reheated in the course of expansion?

It is obvious that the decision in a concrete case will be governed by a series of factors varying with the condi-

* Reprinted by permission of the publisher from *Brown Boveri Review*, Vol. 43, Issue No. 12, pp. 515–524. The first part of this article appeared in COMBUSTION, February 1957, pp. 51–58.

tions in a particular installation, thus making it impossible to generalize. Nevertheless, the complex relationships allow certain rules to be recognized which enable us to arrive very nearly at the correct solutions. Certain optimum conditions, which act as a measure of the quality of practical designs, can be calculated. In this article only simple steam- and gas-turbine cycles are considered. The more complex cycles will be met later.

Utilization of the Heat in a Steam Turbine

The heat carrier heats a boiler in which feedwater, preheated by bled steam, is brought to boiling point and evaporated (Fig. 1). Since we are looking for the optimum solution, we must aim at an exchange of heat between the carrier and the steam in pure counterflow. Then, as far as conditions allow, the steam can also be superheated. If we forego counterflow, for instance by employing a tube-heated boiler drum, the installation will have a performance about 7 per cent poorer considering a random example ($(\vartheta_1 = 229°C, \vartheta_2 = 382°C)$.[1]

Fig. 2 shows a diagram of the temperatures of the heat carrier and the working medium in the heat exchanger. θ_1 and θ_2, the lower and upper temperature limits of the carrier, are given, as stated earlier. We must now decide on three quantities, the values of which we can choose freely within certain limits. These are (1) the feedwater heating temperature, (2) the evaporation temperature (i.e., boiler pressure), and (3) the superheating temperature.

The efficiency with which the heat is converted to mechanical energy is a function of these three quantities. The exact determination of the absolute optimum is very complicated. It was therefore decided to adopt a very simple, clear and sufficiently accurate method, which will now be described.

Determining Optimum Efficiency

If an amount of heat dQ contained in a carrier at a temperature of θ is transferred to a working medium at a temperature T (where $T < \theta$), the energy available for performing mechanical work is reduced by the amount

$$\mathrm{d}Q\left(\frac{T_0}{T} - \frac{T_0}{\theta}\right)$$

where T_0 is the ambient temperature. In the steam turbine the heat of the steam when it reaches the condenser has been utilized until the temperature is nearly down to the ambient level (unlike the gas turbine) and the actual loss corresponds to the above devaluation multiplied by the thermo-dynamic efficiency of the turbine (approx. 80 per cent). Thus it is evident that the temperature T must be as close as possible to θ. But a limit is set to this by the cost of the heat exchanger, which increases as $\theta - T$ decreases. If we have established the sum of money A which is permissible to spend to gain one kilowatt of power (or reduce losses by 1 kw.), we can then capitalize the power losses and so calculate the total costs for the losses and for the exchanger:

$$C\mathrm{d}Q = A\ \mathrm{d}Q\,\eta_T\left(\frac{T_0}{T} - \frac{T_0}{\theta}\right) + B\,\frac{\mathrm{d}Q}{k(\theta - T)}$$

in which

A = Admissible investment per kw gained
η_T = Turbine efficiency
B = Cost of exchanger per square metre
C = Total cost of transferring one unit of heat per unit of time
k = Transmission coefficient of the heat exchanger

Let us refer to the transfer costs as Ψ, obtained by dividing the above equation throughout by $A\mathrm{d}Q\eta_T$.

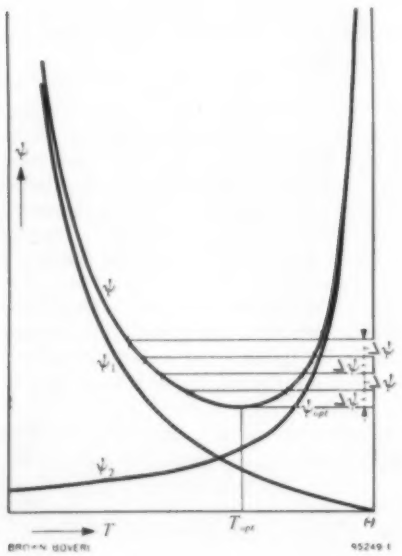
$$\Psi = T_0\left[\left(\frac{1}{T} - \frac{1}{\theta}\right) + \left(\frac{a^2}{\theta - T}\right)\right]$$

in which

$$a^2 = \frac{B}{AkT_0\ \eta_T}$$

Ψ should be kept as low as possible. Hence, the nearer T is to θ (Fig. 3), the smaller the term in the first

[1] The symbols of absolute temperature (°K) are large characters, while small are used for temperatures on the Centigrade scale (°C).



T = Upper temperature of working medium
T_0 = Lower temperature of working medium
Θ = Temperature of heat carrier
ψ = Economic loss index (see text)
a = Investment cost ratio (see text)

$$\psi = T_0\left[\left(\frac{1}{T} - \frac{1}{\Theta}\right) + \frac{a^2}{\Theta - T}\right]$$

$$\psi_1 = T_0\left(\frac{1}{T} - \frac{1}{\Theta}\right)$$

$$\psi_2 = T_0\,\frac{a^2}{\Theta - T}$$

If a small amount of heat **dQ** from the carrier at temperature Θ is transferred to the working medium at T and utilized to T_0, this transfer is most economical when $T = T_{opt}$.

Fig. 3. — To determine the optimum temperature of the working medium

Q/Q_{tot}: see Fig. 2

Θ, T and ψ: see Fig. 3

An evaporation cycle, as in Fig. 2, should be so arranged that the peaks *C*, *D*, *E* and *F* are on lines having equal values of $\psi + \Delta\psi$

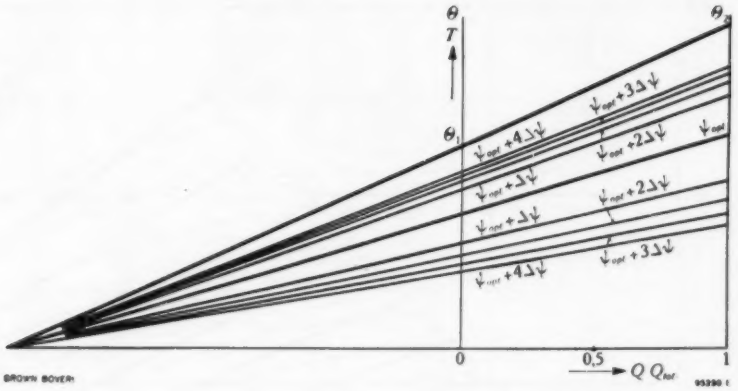


Fig. 4. — Temperature diagram with lines of equal economic losses

bracket becomes and the larger that in the second. The minimum cost is found by differentiation

$$\frac{d\Psi}{dT} = -\frac{T_\theta}{T^2} + \frac{a^2 T_\theta}{(\theta - T)^2} = 0$$

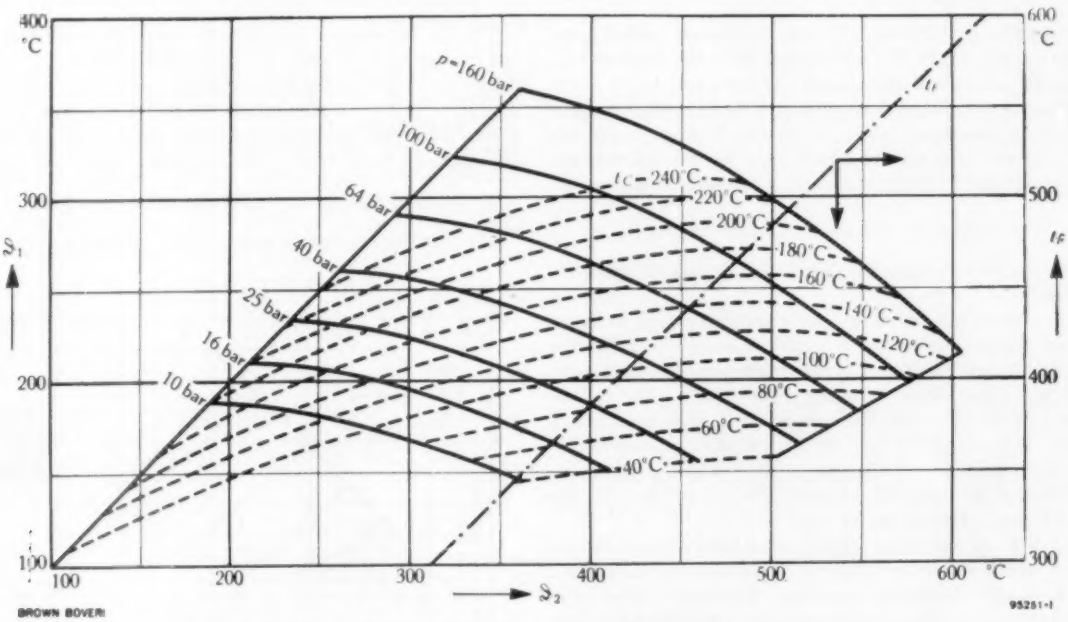
$$\left(\frac{\theta - T}{T}\right)^2 = a^2$$

$$\frac{T}{\theta} = \frac{1}{1 + a}$$

If we now represent the variable temperature θ of the carrier, as a function of the heat given up, by a straight line (corresponding to constant specific heat), the temperatures at which heat absorption is most favorable are on a second straight line situated in the ratio $1/(1 + a)$ with respect to the first and intersecting it at $T = 0$ (Fig. 4). Below and above this optimum line Ψ increases by the amount $\Delta\Psi$. It is possible to draw various straight lines of this nature and label them with $\Delta\psi$ or $\Delta\Psi/\Psi_{opt}$ as the case may be. Now the obvious step is to choose a steam cycle, as per Fig. 2, between two rays having the smallest possible $\Delta\Psi$ values. This method, however, will not produce a rigorous optimum, but it will certainly provide solutions deviating only slightly from the ideal. On checking, deviation was found to be approximately 0.5 per cent.

For heat exchangers of the type likely to be employed in atomic power plants, a is very small in proportion to unity, as shown by the following example.

$$B = 250\ \text{Fr/m}^2 \qquad \eta_T = 0.8$$



ϑ_1 = Lower temperature limit of carrier in °C

ϑ_2 = Upper temperature limit of carrier in °C

t_o = Lower temperature of working medium = 27 °C

——— = p = Steam pressure in bar

– – – – = t_C = Feed-water temperature in °C

–·–·– = t_F = Steam temperature in °C (dependent only on ϑ_2: $T_F = \frac{\Theta_2}{1+a}$)

For example, when ϑ_1 = 250 °C and ϑ_2 = 400 °C, we have p = 54 bar, t_C = 165 °C and t_F = 386 °C.

Fig. 5. — Optimum steam-turbine cycles as a function of the upper and lower temperature limits of the heat carrier

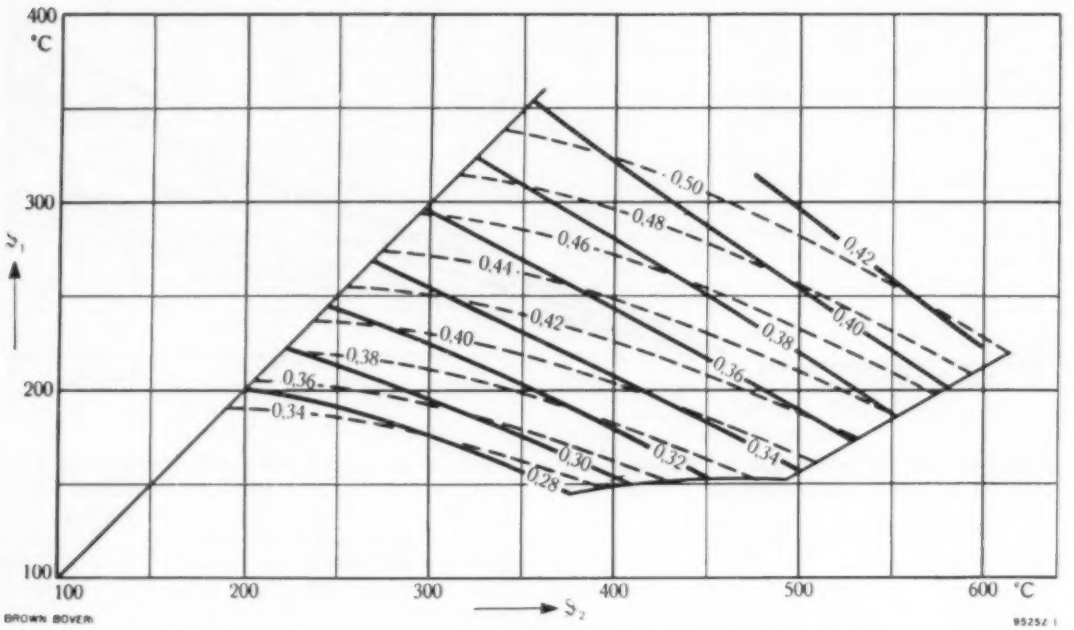


Fig. 8. — Cycle efficiency ηp (– – – –) and thermal efficiency ηth (———) for an output of 100 MW at the coupling and optimum steam cycles as in Fig. 5

A = 1000 Fr/kw	a^2 = 0.0004
k = 2.6 kw/m² K	a = 0.02
T_0 = 300°K	T/θ = 0.98

Under these circumstances, and dispensing with greater accuracy, the peaks D and F taken from the evaporation line in Fig. 2 were plotted on the straight line $T/\theta = 0.98$. Strictly speaking these peaks should be somewhat higher; the efficiencies would then be slightly higher. With the wide variety of a values which may be considered, the results obtained represent a cautiously determined mean.

Establishing Optimum Efficiency Curves

The following diagrams depict the results of these investigations.

Fig. 5 gives the optimum cycle corresponding to every pair of temperatures (ϑ_1; ϑ_2) and characterized by the steam pressure, feedwater heating temperature and superheating temperature. Among other things, the curves show that in the borderline case when $\vartheta_1 = \vartheta_2$ a saturated steam cycle should be used with preheating to the saturation temperature. This also applies when there is no heat exchanger and the evaporation takes place in the reactor itself (boiling-water type).

Fig. 6 gives the cycle efficiency of steam plants as per Fig. 5 which would be obtained with loss-free expansion and reversible feedwater heating. The same curve gives the thermal coupling efficiency of an actual turbine having an output of, say, 100 MW, the following loss factors having been taken into account in the calculation:

Losses in the "dry" turbine (referred to an isentrope)	= 0.15
Braking effect of water at a mean water content $(1 - \bar{x})$	$= 0.6\ (1 - \bar{x})$
Losses attributable to non-reversible feedwater heating	= 0.015–0.01

For the purpose of comparison, Fig. 7 gives the theoretical efficiency of completely reversible conversion of the heat contained in the temperature range $\vartheta_1 \leq \vartheta \leq \vartheta_2$. The comparison of the actual steam- or gas-turbine diagrams with this curve serves as a measure of the shortcomings of the thermal machines and cycles.

Utilization of the Heat in a Gas Turbine

Fig. 8 is the schematic diagram of a gas turbine utilizing

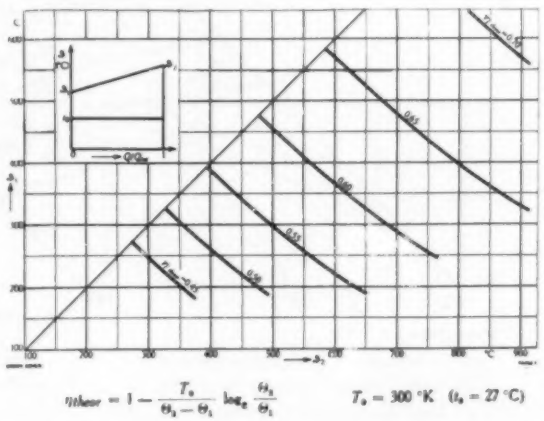
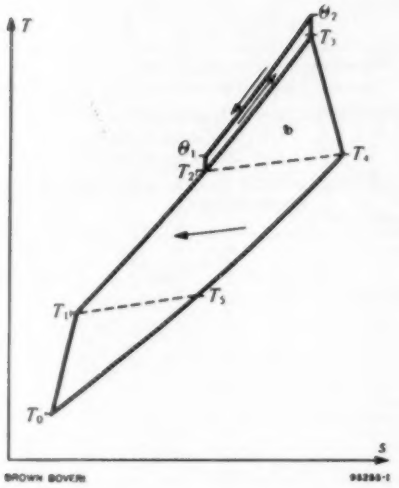


Fig. 7. — Theoretically obtainable efficiencies η_{theor} with completely reversible utilization of a heat source with constant specific heat



For the working medium

T_0 = Temperature before the compressor
T_1 = Temperature after the compressor
T_2 = Temperature after heating in preheater
T_3 = Temperature after heat exchanger
T_4 = Temperature after the turbine
T_5 = Temperature after cooling in preheater

For the carrier

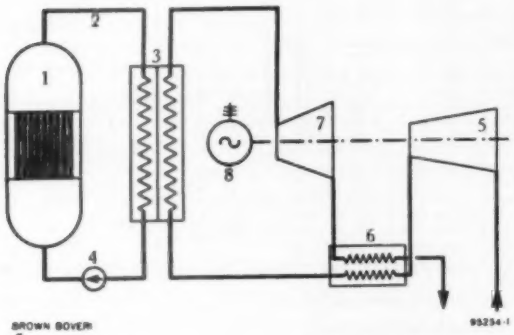
Θ_1 = Temperature after cooling in heat exchanger
Θ_2 = Temperature before cooling in heat exchanger

Fig. 9. — Entropy diagram of the simple gas turbine in Fig. 8
s = Entropy

energy contained in a heat carrier. Let us first examine the simplest form of gas turbine, having simple compression without inter-cooling, air preheated by turbine exhaust gases, air heated by carrier in heat exchanger, and simple expansion without reheating.

Fig. 9 is the corresponding entropy diagram. The working air must be heated from the heat carrier by counterflow, for which we will first assume a constant temperature difference between one medium and the other along the transfer surface. The magnitude of this difference is obtained from considerations similar to those in the previous chapter. We will, therefore, not bother further with these details, but will insert a drop of 15 K in the diagram, thus assuming the temperatures of the working medium before and after heating to be given (T_2, T_3).

If we had no air preheater we would have to compress the air until its temperature rose to T_2. Under certain circumstances this may be a suitable compression pressure. In the present case, however, we choose the compression pressure at which maximum output is obtained. Therefore the air temperature is increased to T_1 by compression, then further to T_2 in the air preheater before the air enters the heater itself.



1 = Reactor
2 = Heat-carrier circuit
3 = Heat exchanger (air heater)
4 = Pump circulating carrier
5 = Compressor
6 = Air preheater
7 = Turbine
8 = Alternator

Fig. 8. — Atomic power plant utilizing nuclear energy in a simple gas turbine

The thermal efficiency of the gas turbine (neglecting variation in specific heat) is

$$\eta_{th} = \frac{T_3 - T_4 - (T_1 - T_0)}{T_3 - T_2}$$

T_0, T_2 and T_3 are fixed, whereas T_1 and T_4 depend on the compression ratio. Let us now introduce $\tau_n = T_n/T_0$; then

$$\eta_{th} = \frac{\tau_3 - \tau_4 - (\tau_1 - 1)}{\tau_3 - \tau_2}$$

In order to be able to differentiate this equation let us substitute for τ_4 in terms of τ_1. Assuming

$$\frac{p_1}{p_0} = \sigma \cdot \frac{p_3}{p_4}$$

where $\sigma = 1 + \Sigma\Delta p/p$ takes into account the pressure drops in the heat exchanger and piping, we have

$$\tau_1 = \left(\frac{p_1}{p_0}\right)^{\frac{x-1}{x\eta_c}}$$

$$\tau_4 = \tau_3 \left(\frac{p_3}{p_4}\right)^{-\frac{x-1}{x}\eta_c} = \tau_3 \left(\frac{1}{\sigma}\frac{p_1}{p_0}\right)^{-\frac{x-1}{x}\eta_c}$$

$$= \frac{x-1}{\sigma^x}\eta_e \tau_3 \tau_1^{-\eta}$$

where η_c and η_e are the efficiencies of compression and expansion, respectively, and $\eta = \eta_c\eta_e$.

In differentiating the efficiency we only need to differentiate the numerator of the fraction (the denominator being constant); it gives

$$-d\tau_4 - d\tau_1 = 0$$

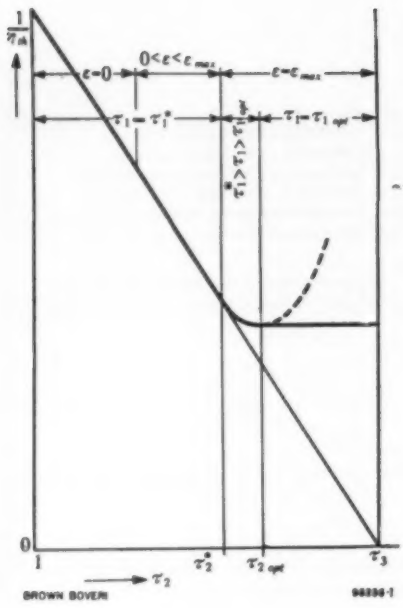
or

$$d\tau_4/d\tau_1 = -1$$

That is to say

$$\eta \cdot \frac{x-1}{\sigma^x}\eta_e \tau_3 \cdot \tau_1^{*-(1+\eta)} = 1$$

where τ_1^* denotes the optimum value of τ_1



η_{th} = Thermal efficiency of plant
ε = Utilization factor of air preheater

Temperature ratios: $\tau_1 = T_1/T_0$ after compressor
$\tau_2 = T_2/T_0$ before the air heater
$\tau_3 = T_3/T_0$ before the turbine

Also plotted are the scope of the air preheater and the range in which τ_1^* can be used.

Fig. 10. — Heat consumption of the simple gas turbine for given temperatures at inlet to compressor (T_0) and turbine (T_3) as a function of temperature at inlet to air heater (T_2)

$$\tau_1^* = \left[\eta\sigma^{\frac{x-1}{x}}\eta_c\ \tau_3\right]^{\frac{1}{1+\eta}}$$

Combining this expression with that for τ_4 we obtain

$$\tau_4^* = \frac{\tau_1^*}{\eta}$$

With these optimum values we obtain the efficiency

$$\eta_{th} = \frac{1+\tau_3-\dfrac{1+\eta}{\eta}\left[\eta\sigma^{\frac{x-1}{x}}\eta_c\tau_3\right]^{\frac{1}{1+\eta}}}{\tau_3-\tau_2} = \frac{Z}{\tau_3-\tau_2}$$

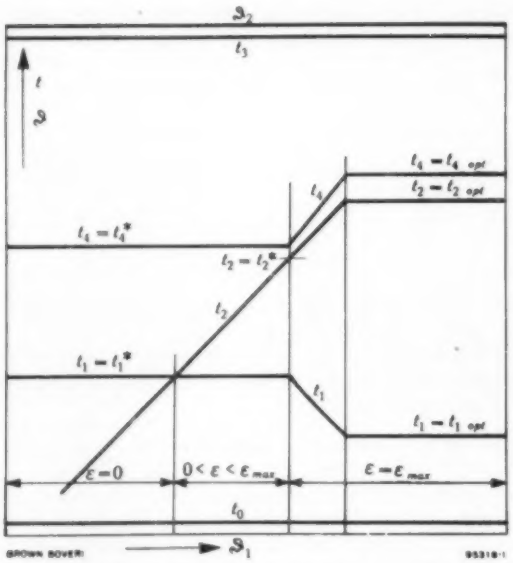
If we consider gas turbines (Figs. 8 and 9) for a given upper temperature τ_3 (expressed by its ratio to T_0) and various temperatures τ_2, we discover that

1. the optimum pressure ratio is independent of τ_2
2. the numerator Z of the above expression is likewise independent of τ_2.

The reciprocal of the efficiency, i.e., the heat consumption, is a linear function of τ_2:

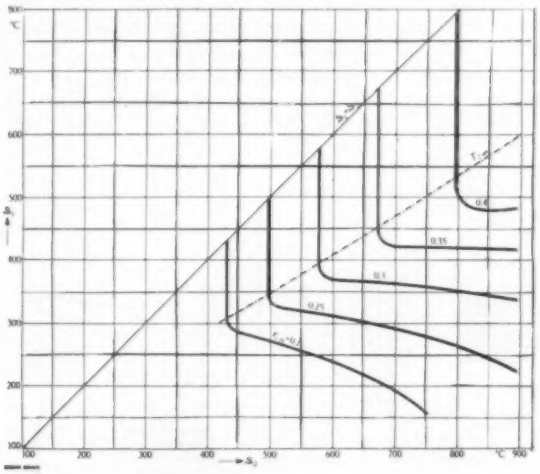
$$\frac{1}{\eta_{th}} = \frac{\tau_3-\tau_2}{Z}$$

This expression only has a meaning provided τ_2 remain below τ_4, as expressed by



Symbols as Fig. 9 and text. Small characters imply temperatures in °C.

Fig. 12. — Temperatures in the gas-turbine cycle at given upper and variable lower temperature limits of the heat carrier

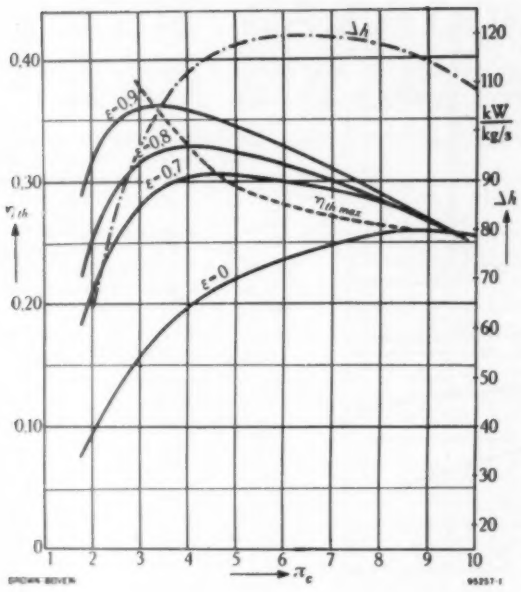


ϑ_1 = Lower temperature limit of carrier in °C
ϑ_2 = Upper temperature limit of carrier in °C

The following numerical values were employed:

$\eta = \eta_c\,\eta_t = 0.75$ $\quad x = 1.4$ $\quad \sigma = 1.07$ $\quad \tau_{max} = 0.9$ $\quad T_0 = 288$ °K

Fig. 13. — Efficiency of the simple gas turbine as a function of the upper and lower temperature limits of the heat carrier



π_c = Pressure ratio of the compressor
ε = Utilization factor of air preheater
——— = η_{th} = Thermal efficiency
– – – = $\eta_{th\,max}$ = Maximum possible thermal efficiency
–·–·– = Δh = Utilized heat drop in kW/kg/s
Temperature before the turbine = 730 °C
Temperature before the compressor = 20 °C

Fig. 11. — Efficiency and useful heat drop of a simple gas turbine with air preheaters having different utilization factors

$$\tau_2 \leq \tau_2 \equiv \tau_1 + \epsilon_{max}(\tau_4^* - \tau_1^*)$$

$\epsilon = (\tau_2 - \tau_1)/(\tau_4 - \tau_1)$ is the utilization factor of the preheater and ϵ_{max} the highest value it can be expected to attain with reasonable means. The heat necessary to bring about the rise from τ_2 to τ_2^* does not increase the power output but merely economizes in exchanger surface area. When τ_2 is below τ_1^*, even this advantage is lost. With the present high cost of nuclear energy, τ_2 must not be allowed to drop very far below τ_2^*.

If $\tau_2 > \tau_2^*$, we can no longer select the pressure ratio according to the previous optimum conditions, but must reduce it until

$$\tau_2 - \tau_1 = \epsilon_{max}(\tau_4 - \tau_1)$$

As illustrated by Fig. 10, the heat consumption drops as τ_2 increases. At τ_{2opt} it attains a minimum after which it would start to rise again. There would, however, be no point in accepting lower efficiency by raising τ_2. Dispensing with the constant temperature difference between carrier and working medium, as stipulated at the beginning of this chapter, the lower temperature is fixed at the optimum value τ_{2opt} thus reducing the heat transfer surface. Lowering the lower temperature limit in a nuclear reactor is welcome in any case. At the optimum point, the pressure ratio corresponds to the most favorable value for a gas turbine with an air preheater having a utilization factor $\epsilon = \epsilon_{max}$ (Fig. 11). Fig. 12 illustrates the above relationships in another manner.

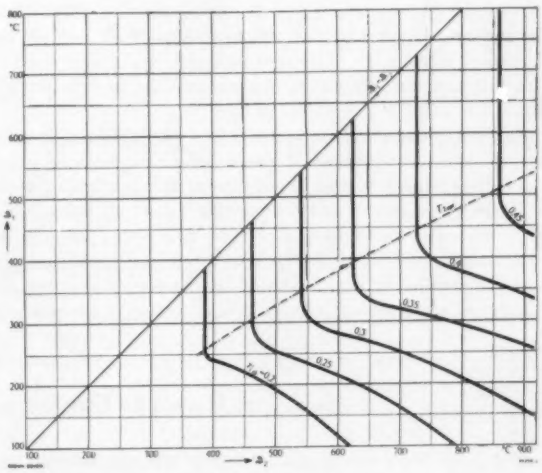
Fig. 13 shows the efficiency of the gas turbine as a function of ϑ_1, ϑ_2. Fig. 14 shows the efficiency of the gas turbine with *one* intercooler in the compressor. As the analysis of such a system follows that outlined above, the remarks will not be repeated. It is merely mentioned that in this case, with $\tau_2 \leq \tau_2^{**}$, conditions are similar to those previously obtained:

$$\tau_1^{**} = \left[\eta \cdot \sigma^{\frac{x-1}{x}} \eta_c \cdot (1 + \delta\tau_0) \cdot \tau_3\right]^{\frac{1}{1+2q}}$$

$$\tau_4^{**} = \tau_1^{**}/\eta$$

where $\delta\tau_0 = \delta T_0/T_0$, δT_0 being the temperature difference in the intercooler.

It is particularly stressed that these results apply equally to an *open-cycle gas turbine* drawing in air from and discharging its exhaust gases to the atmosphere, as to a *closed-cycle gas turbine* in which the exhaust air (or gas) is recooled to its initial state. Similarly, the considerations also apply to direct heating of the working gas in the reactor, when T is made equal to θ, and provided T_2 is not higher than T_{2opt}.



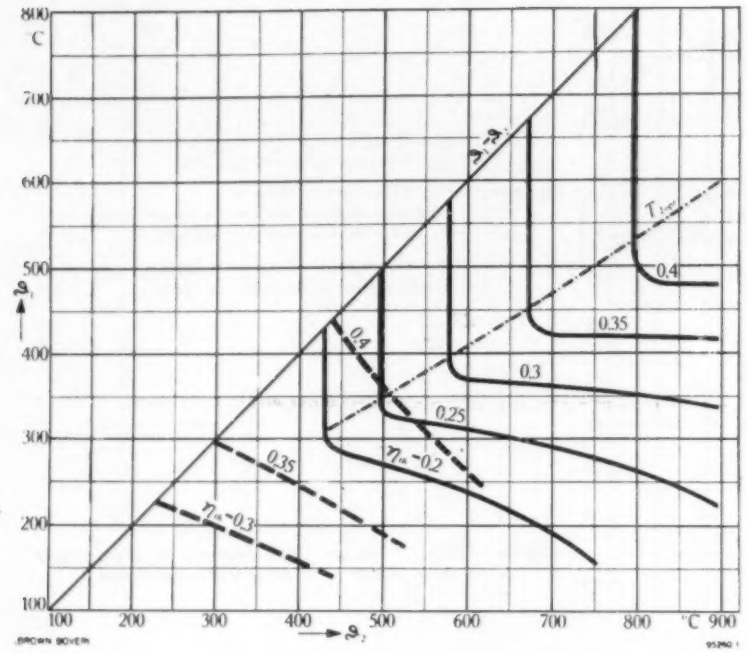
ϑ_1 = Lower temperature limit of carrier in °C
ϑ_2 = Upper temperature limit of carrier in °C

The following numerical values were employed:

$\eta = \eta_c\,\eta_e = 0.75$ $\quad x = 1.4$ $\quad \sigma = 1.07$ $\quad \epsilon_{max} = 0.9$ $\quad T_0 = 288$ °K

Temperature difference in intercooler 15 C

Fig. 14. — Efficiency of the gas turbine with one intercooler



The curves illustrate the thermal efficiency referred to the output at the coupling of a plant with an electrical output of 15 MW.

——— = η_{th} for the gas turbine
—·—·— = Along this line $T_3 = T_{3\,opt}$
– – – – = η_{th} for the steam turbine
ϑ_1 = Lower temperature limit of carrier in °C
ϑ_2 = Upper temperature limit of carrier in °C

Fig. 15. — Comparison of simple steam- and gas-turbine plants without intercooler for different temperature limits of the heat carrier

Conclusions

For the heat which a carrier can supply in a given temperature range we have determined the most favorable simple steam- and gas-turbine cycles. For every pair of temperatures within the range examined it is possible to read off the efficiency from Figs. 6, 13 and 14. It is then discovered that the rules on which the calculations are based, referring to one machine or the other, are quite different, also the shapes of the efficiency curves for the two kinds of machine are unlike. Two sets of curves are shown in Fig. 15. Above all, it is clear that the regions covered by the steam and gas turbines are by no means identical. The temperatures suitable for quite efficient steam turbines with pressures up to 160 bar are much too low for gas turbines.

In the temperature range suited to gas turbines, it is no longer possible to design a steam plant capable of gaining full thermodynamic benefit from the particular temperatures, provided only a simple plant is considered with sub-critical pressures. It is, however, possible to "throttle" the heat down to lower temperatures and obtain efficiencies as high as those in the region covered by the diagrams; in fact, even higher efficiencies are possible since superheating can be carried out to higher levels without exceeding the range of ordinary steam plants. It is, of course, possible to proceed to supercritical pressure and multiple superheating, as was demonstrated in the first article under this title, and thus to compete still more seriously with the efficiency of the gas turbine, although the cost is very high and can only be considered for large outputs. For high temperatures and moderate outputs the gas turbine—open- or closed-cycle, according to the circumstances—is certainly justified, although local conditions will exert a deciding influence.

In many cases the temperature range of the carrier is not defined from the start, as was assumed, but, on the contrary, is open to discussion. It is hoped that the diagrams reproduced here will prove useful by giving immediate indication of the consequences of choosing particular temperatures, thus assisting general economic planning.

It is intended to extend the scope of these systematic investigations in a further article, which will cover supercritical steam pressures and multi-stage heating in steam and gas turbines.

Sodium Reactor Experiment Achieves Nuclear Fission

On Apr. 25, 1957, self-sustaining nuclear fission was achieved in the Sodium Reactor Experiment, a small-scale experimental civilian atomic power project being developed for the Atomic Energy Commission near Los Angeles by Atomics International, a division of North American Aviation, Inc., the AEC announced recently.

The SRE uses neutrons moderated with graphite to sustain the fission process, and liquid sodium is circulated through the reactor core to remove heat produced by the atomic fission. During the initial start-up test the reactor operated at a power level of about one kilowatt of heat. No electricity was generated. The design capacity of the SRE is 20,000 kilowatts of heat.

During the next several weeks numerous tests will be made to establish satisfactory operation.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Heat Exchangers

The design and construction of finned tube units, known as G-R K-Fin Coolers, manufactured by Griscom-Russell Co. for both air and hydrogen circulated through the generator windings in a closed system makes up the subject matter of a 12-page bulletin, No. 1200. The application of each type of unit as applied to generators is illustrated and explained, and the bulletin is illustrated with drawings and photographs of the details of each design. Reference is also made to the applications of these coolers to air and gas cooling or heating services in chemical process plants and other industrial plants.

Pneumatic Pressure Transmitters

Pressure and differential pressure transmitters utilizing a "null-balance-vector" principle have been added to Republic Flow Meters Co. line of power and process instruments. These devices are described in separate 4-page brochures, Folio 56-12 for the pressure transmitter, and Folio 56-13A for the differential transmitter. The new design principle is said to permit greater compactness, reduce weight, and permit stepless changing of each instrument's range with a simple "screw-driver adjustment." The latter is accomplished by changing the angle at which input forces are applied to the linkage, thereby altering the component of such forces that must be balanced. Standard models of both instruments operate on 20 psi air and produce output signals from 3 to 15 psi, normally using about 0.2 scfm of air.

Instrument Specification

Publication 57-687-297, The Hays Corp., presents in 12 pages a digest of specifications of instruments and controls manufactured by this concern.

Reference Manual

Selecting asbestos textiles for any application or temperature range is materially simplified by a new reference manual just published by Union Asbestos & Rubber Co. Designed to fit standard source files, this 16-page book, UNARCO publication 76-327, available by writing on business letterhead, is reputed to contain all the information a product engineer or designer needs to guide his selection of asbestos textiles for any use from blast furnace door packing to theater curtaining. Products covered include cloth, tape, tubing, lap, roving, cord, wick, and appropriate pictures. In nonmetallic and metallic cloth, alone, there are 76 different selections.

Nuclear Filtration

The Cuno Engineering Corp. has recently released a new 6-page folder, catalog No. 54–102, covering its complete line of filters and filtration systems for use in nuclear power and research applications. It is believed that this is the first publication ever issued that is devoted entirely to this aspect of atomic energy development. Descriptions are supplied of the characteristics of the various filter types and media used in the nuclear field and fifteen of the principal types of nuclear power applications are given for these filter units. Several specific filter types of particular interest to nuclear scientists and engineers are described and illustrated.

Standard Screw Pumps

Basic construction and design of a line of standard screw pumps are shown in a new bulletin, S-206, of Warren Pumps, Inc. Featured are those of double external bearing and gear type, and double external bearing and gear hopper type.

Car Puller

The Jones Machinery Division of Hewitt-Robins, Inc., has published a new 32-page booklet, bulletin J-11, on car pullers. The booklet contains a description of several installations and describes various types of car pullers for moving freight cars, barges, scrap buggies, furnace cars and many types of industrial transfer cars.

Semi-Steel Valve

A completely revised 43-page bulletin (V-203, Rev. 1) covering the entire Rockwell-Nordstrom semi-steel valve line has been issued by Rockwell Manufacturing Co. The new bulletin supersedes a 35-page earlier edition and offers a number of entirely new features including: (1) two full pages of photos, drawings and detailed description of Rockwell-Nordstrom lubricants and lubricating methods; and (2) large cutaway photos showing in detail the working parts of four principal types of Rockwell-Nordstrom semi-steel valves—two-bolt cover, screwed-gland, bolted-gland, and multiport types. Other features include photos and larger easier-to-read specifications tables— and photo-illustrated descriptions of all new semi-steel models added to the line in the past four years.

Belt Conveyor Idlers

The C. O. Bartlett & Snow Co.'s 8-page bulletin No. 119 describes complete line of belt conveyor idlers including troughing, flat, self-aligning, rubber disk and return designs; —4-in., 5-in. and 6-in. diam rolls; —fitted with either Timken or "Sealed for Life" bearings; —describes the construction, lists standard sizes, dimensions, weights.

Automatic Valveless Filter

An 8-page bulletin describing fully the operation of the company's automatic valveless filter has been released by The Permutit Co. and bears the title, "Automatic Valveless Filter." The manufacturer claims this filter can be used wherever gravity flow is feasible; with this new automatic equipment, instrumentation and auxiliaries are eliminated, manpower and maintenance are reduced to minimum requirements.

Zirconium, Zircaloy Properties

The physical properties of zirconium and the Zircaloys and the mechanical properties of three different tempers of these metals have been published for the first time in Special Analysis Memorandum No. 112 issued by Superior Tube Company.

The three tempers are fully annealed, half-hard drawn and full-hard drawn tubing. The memorandum points out that in addition to these three standard tempers, the manufacturer can produce tubing to special tempers such as $^1/_8$ hard, $^1/_4$ hard, $^3/_4$ hard and stress relieved.

The physical and mechanical properties listed are for reactor grade zirconium, Zircaloy-2 and Zircaloy-3. The memorandum emphasizes that production of tubing from these three metals is limited at the present time to a conversion basis because of the limited availability of reactor grade sponge for commercial use.

Temperature Pipe and Block Insulation

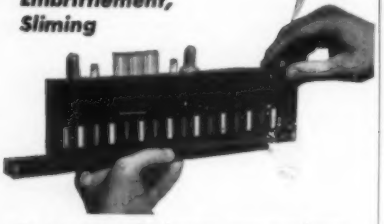
Ehret Magnesia Mfg. Co.'s 6-page bulletin, "New Ehret Thermasil," cov-

fast, accurate tests for pH, PHOSPHATE, NITRATE

with

TAYLOR COMPARATORS

Help Control Scaling, Corrosion, Embrittlement, Sliming



In a matter of minutes, you can have accurate determinations of pH, phosphate, nitrate or silica content by making on-the-spot colorimetric tests with lightweight, portable Taylor Comparators. No technical knowledge or experience is required to get dependable operational data. Testing consists of comparing the treated sample with the movable color standard slide until colors match. You then read values direct from slide. All Taylor sets come complete with necessary accessories, reagents and instructions. Complete water analysis is only a little more detailed with the Taylor Water Analyzer.

To determine water hardness quickly, yet with the ease and accuracy of an alkalinity titration, use the Taylor Total Hardness Set.

COLOR STANDARDS GUARANTEED

Be sure to use only Taylor reagents and accessories with Taylor Comparators to assure accurate results. All Taylor liquid color standards carry an unlimited guarantee against fading.

SEE YOUR DEALER for Taylor sets or immediate replacement of supplies. Write direct for **FREE HANDBOOK, "Modern pH and Chlorine Control".** Gives theory and application of pH control. Illustrates and describes full Taylor line.

W. A. TAYLOR AND CO.
416 RODGERS FORGE RD. • BALTIMORE, MD.

ers the company's line of calcium silicate insulation for temperatures up to 1200 F. The bulletin gives basic sizes of insulation for pipe covering and block for process vessels or other equipment. Included also are data on basic features which suit the new material to present-day requirements. Physical properties are tabulated and thermal conductivity given in graph form.

Hot Lime Zeolite

The application of hot lime zeolite to moderate high pressure (600–700 psig) boiler operations was the subject of a recent paper presented by B. E. Varon, superintendent of utilities, Richfield Oil Corp., and S. B. Applebaum, director, water treatment division, Cochrane Corp., at the American Power Conference in Chicago. This paper is available as Reprint No. 113 of Cochrane Corp. and gives this refinery's experience with two boiler plants. A full history of the boiler and turbine conditions at both boiler plants is given.

Self-Closing Pipe Insulation

Complete specifications for Mono-Kover, a slit, one-piece, sectional type molded mineral wool pipe insulation that snaps into place, are presented in a new 4-page, three-color bulletin just published by the Baldwin-Hill Co. In addition to describing completely the insulating properties of the material, the pamphlet explains and illustrates approved application methods. Thermal conductivity is shown graphically for every temperature throughout its operating range (to 350 F).

The bulletin lists and describes the various facings for the material which are available and presents, in tabular form, thicknesses recommended to insulate pipe sizes from $^3/_4$ in. to 24 in. according to temperature and type of application. Types of application include: industrial, commercial, institutional, hot water, low pressure steam, cold piping and dual temperature service.

Turbine Drives

High-speed multi-stage steam turbines to drive boiler feed pumps in steam-electric generation stations of 150,000 kw capacity and above are described in a new General Electric Co. publication designated GEA-6541, a two-color, 16-page issue.

Graphs illustrate the economical advantage of steam turbines for boiler feed pump drives, and the amount of additional salable kilowatts made possible through the use of these turbines. Cycle arrangements for both condensing and non-condensing turbines are also included.

New Betz Technical Paper

Betz Laboratories, Inc., recently announced the availability of two technical papers. One, No. 134, is entitled "Biological Fouling in Recirculating Cooling Water Systems," and discusses the common problems of slime and algae in these systems and points out how deposits of biological origin can interfere seriously with heat transfer.

The second paper, No. 135, is entitled "Conductivity Versus Sodium by Flame Spectrophotometer in Steam-Purity Studies," and it presents results of extensive laboratory and plant work to indicate that sodium is extremely valuable in evaluating steam purity. It is far superior to conductivity and is sensitive enough to detect the solids and the wetness of steam of very high quality.

High-Pressure Gas Regulator

A newly revised 8-page bulletin, No. 1024–6, describing the company's complete line of high pressure regulators has been issued by Rockwell Mfg. Co. An important new feature is a page of description, photos and drawings of the recently introduced high-pressure "141" regulator, which will withstand momentary overloads as high as 1,000 psi on the outlet side without damage to the regulator and a description of the high-pressure "173" regulator in greatly expanded detail with new photos and drawings illustrating several typical hook-ups.

Pipe Fabrication

A 16-page brochure, "How Piping is Fabricated," shows how the recently formed fabrication team of Flori Pipe Co. and Houston Pipe & Steel, Inc., both subsidiaries of the Sparton Corp., combine their facilities and technical knowledge on piping fabrication from the preparation of bids to delivery of the finished job. The brochure photo-

UNAFRAX CONSTRUCTION CO.

LO. 3-2431 UC Co. **PGH. PA.**

ORGANIZED IN 1956 BY
P. C. FOCER AND PAUL I. NEFF
AFTER COMPLETE DISSOLUTION OF
UNITED REFRACTORY CONST. CO.

"LET **UNAFRAX** SOLVE YOUR REFRACTORY AND INSULATION CONSTRUCTION PROBLEMS FOR BOILERS—FURNACES KILNS—INCINERATORS"

405 MCNEILLY ROAD
PITTSBURGH 26, PA.

graphically illustrates equipment, materials and processes, including pipe bending facilities, welders, x-ray machines, heat-treating furnaces, pipe and fittings inventories and other facilities for accurate, quality piping fabrication.

Large Steam Turbines

Advances in the field of large steam turbines is the subject of a new literature release, 03R8620, by Allis-Chalmers Mfg. Co. It is based on a paper by C. D. Wilson, chief turbine design engineer of Allis-Chalmers steam turbine department, and was presented before the 19th annual meeting of the American Power Conference. The 12-page booklet covers a number of significant developments of interest to the power field including the world's first 300-mw unit for Detroit Edison, using the close-coupled, cross-compound arrangement; a 250-mw centerline-at-floor-level unit for the Oak Creek station of Wisconsin Electric Power Co., and tandem triple-flow units in the 200 to 250-mw range, representing the currently large ratings for 3600-rpm single-shaft machines.

Corrosion Resistant Fittings

A 24-page, two-color catalog has recently been made available by the Horace T. Potts Co. for their Speedline fittings, corrosion-resistant materials for service with stainless steel piping. The catalog features specification tables, welding suggestions, application suggestions and general piping information.

Deaerators

A new 8-page technical booklet entitled, "Safeguarding Your Boiler Plant Equipment with L-A Deaerators," is now available from the L-A Water Softener Co. The bulletin, numbered 102-A, describes the complete course of all water through the stainless-steel deaerator. A cutaway photographic type drawing of the entire unit, plus a close-up detail drawing of the newly designed all stainless-steel head section, trace the path of particles of water from entrance to storage in the deaerator tank.

Sample specifications and detail charts of the capacities and dimensions of over 30 different models of 10 minute and 2 minute storage L-A deaerators are given with engineering drawings of typical layouts.

Expansion Joint

The new Yarway type W Gun-Pakt expansion joint is described in an 8-page bulletin, No. EJ-1915, which features an improved one-piece design of body and gland to eliminate the customary bolted joint between body and gland. Data are provided on how to figure expansion of pipelines and suggestions for installation of expansion joints.

Feedwater Control

Copes-Vulcan Division, Blaw-Knox Co., in their bulletin No. 1028, describes the company's new Type P regulator for remote control of boiler feedwater in stationary and marine service. The system modulates boiler-water feed by up to three influences—drum-water level, feedwater flow and steam flow. The 4-page bulletin discusses the primary elements, and illustrates the schematic hook-ups of this system for simple-level, Flowmatic and Balanced-Flow control.

Automation System

The Cottrell automation system recently announced by Research-Cottrell, Inc., known as the CA system, is said to bring complete automation to the power inputs of electrostatic precipitators, eliminating manual adjustments

EXTRA YEARS
OF MORE DEPENDABLE POWER
and at less cost per pound of steam

TODD BURNERS
GAS OR OIL
PRODUCTS DIVISION
TODD SHIPYARDS CORPORATION

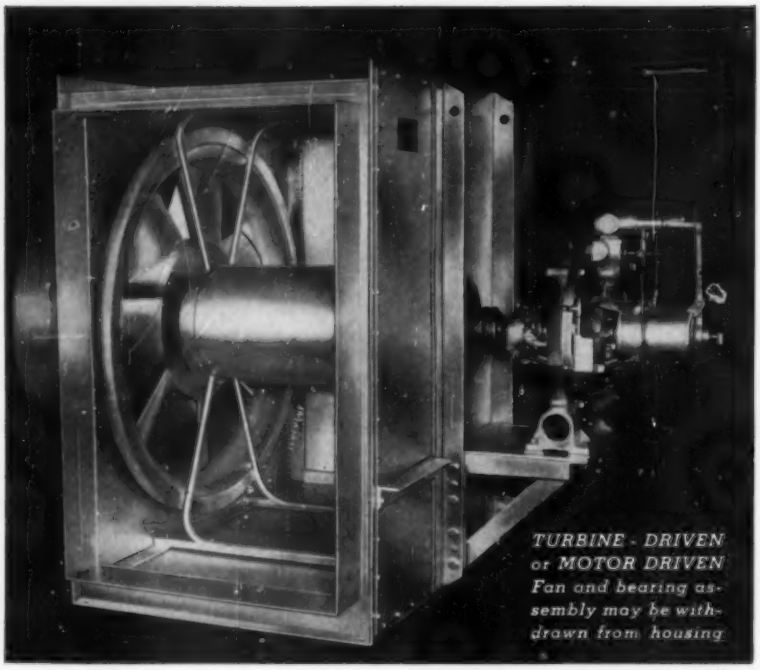
HEADQUARTERS: Columbia & Halleck Streets, Brooklyn 31, N. Y.
PLANT: Green's Bayou, Houston 15, Texas

TODD NEW YORK, U.S.A.

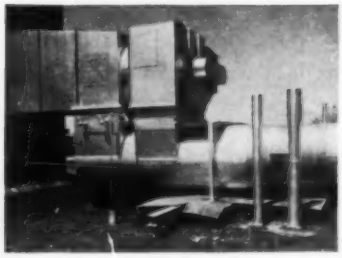
DEOXY-SOL
SOLUTION OF HYDRAZINE

- Oxygen-
- Scavenger
- for
- Boiler Water
- Treatment

FAIRMOUNT CHEMICAL CO., INC.
136 Liberty St., New York 6, N. Y.
Midwestern Representative:
J. H. DeLamar & Son, Inc.
4529 No. Kedzie Avenue
Chicago 25, Ill.
Ask for pamphlet BW-5



Draft Inducer for Power Plants



- BIG SAVINGS IN SPACE
- NO WATER COOLING OF BEARINGS
- NO FAN BEARING LUBRICATION NEEDED
- INTERCHANGEABLE INLETS: TOP, BOTTOM OR SIDES
- EASY TO INSPECT AND MAINTAIN

L. J. Wing Mfg. Co. 54 Vreeland Mills Road, Linden, N. J.

· Wing ·
DRAFT INDUCERS

WING MOTORIZED BLOWERS

WING TURBINE BLOWERS

WING TURBINES

WING REVOLVING-HEATERS

CO-6
L. J. Wing Mfg. Co.,
54 Vreeland Mills Rd., Linden, N.J.
Please send copy of Draft Inducer Bulletin I-57.
Name.....
Firm.....
Address.....
City..... Zone..... State.....

and increasing round-the-clock dust and fume collection efficiencies.

An 8-page illustrated bulletin describes this system, defines the term "Ideal Electrical Power" and demonstrates by means of comparative charts how this precipitator power level, required for optimum performance, can be much more closely approached by automation than by the manual control. Additional benefits of the CA system, such as lower operating costs and greater utilization of installed electric power are outlined.

Motor Tractors

Three new scrapers and a new overhung engine bottom-dump are described in literature just issued by Euclid Division of General Motors Corp. Models SS-18 and SS-24 are 4-wheel tractor type scrapers with struck capacities of 18 and 24 yds and 300-hp engines with torqmatic drives. The model S-12 bottom-dump is an overhung engine tractor with semi-trailer of 13 cu yds struck capacity which is interchangeable with a 12 yd scraper bowl.

The model TS-24 is an overhung engine type twin power scraper with a capacity of 24 yds struck and 32 yd heaped at S.A.E. 1:1 slope. It is powered by two engines—300 hp with torqmatic drive for the tractor and 218 hp with torqmatic drive for the scraper axle.

Air Compressor

Ingersoll-Rand Co. announced a new air compressor described in an 8-page bulletin, Form 1547, to be known as the "Channel-Flow." It is a two stage, 200 psig rated motor compressor presently available in $1^1/_2$ and 2-hp sizes. The complete packaged unit includes the motor compressor, cushioned rubber mounting on an ASME vertical tank, interconnecting piping and fittings and automatic start-and-stop control.

The manufacturer claims important safety and space-saving features in this new unit. Troublesome and hazardous belt drive is eliminated because the compressor is flange-mounted directly on the driving motor. Due to this direct mounting, the unit requires less than half the floor space of tank-mounted, belt-driven units of comparable size. It can also be mounted on a shelf, side wall or overhead bracket with the air receiver located in an out-of-the-way space.

Retractable Soot Blowers

Bulletin No. 1030, recently published by Copes-Vulcan Division, Blaw-Knox Co., describes the Vulcan T-30 retractable soot blowers presently available in lengths up to 38 ft. Clear cross-sectional drawings explain the workings

of all moving parts and actuating components. Also listed are special design features which assure effective tube cleaning and long trouble-free performance. The T-30 is designed to clean the widest furnaces as well as withstand the severe requirements of outdoor service.

Personals

Donald F. Fraser, formerly production manager, was elected vice president in charge of manfacturing of The Garlock Packing Co., Palmyra, New York, at a recent meeting of the board of directors. **Albert J. McMullen** was also elected a vice president. Mr. McMullen is president of the United States Gasket Co., of Camden, N. J., plastics division of Garlock. He is a member of the parent company's board of directors.

Five Detroit Edison men have won their company's annual Alex Dow Award for outstanding achievement. This year's winners are **Frank C. Carleton, John C. Kennedy, Arthur H. Pfander, Harry E. Richards,** and **Willian A. Zander.** The awards, established in 1946 and named in honor of the electric industry pioneer who headed Detroit Edison for 28 years, were presented by Edison president Walker L. Cisler.

The appointment of **Carl W. Larsen** as executive assistant for public information at Argonne National Laboratory has recently been announced. Mr. Larsen joined the Laboratory April 15 after serving as Chicago area representative for the U. S. Information Agency, the government's overseas information program.

Homer E. Lunken, vice president and a director of the Lunkenheimer Co., has been elected national president of the Society for Advancement of Management, for the fiscal year beginning July, 1957. The Society is the professional organization of management people in industry, commerce, government and education, with national, regional and chapter activities.

The election of **Edward E. Slowter** as vice president of Battelle Institute was announced recently. A member of Battelle's technical and executive staff since 1936, Slowter has been the foundation's secretary and business manager.

The appointment of **Harry M. Pier** as executive secretary of the Air Pollution Control Association was recently announced. Mr. Pier leaves his post as assistant to the chairman of Research-Cottrell, Inc., to take his new assignment on June 1. Mr. Pier in his new position will also serve as senior fellow of the Multiple Air Purification Fellowship in Mellon Institute, Pittsburgh.

Samuel R. Parry was recently elected a vice president of Combustion Engineering, Inc. Mr. Parry has been associated with Combustion since 1923 and will continue as general manager of the Chattanooga Division, which is the company's largest manufacturing operation.

Crane Co. has recently announced the election of **Joseph W. Greene** as vice president of sales. Mr. Greene, who moves up from his post as director of industrial sales, will head a realigned department organization which will coordinate industrial, plumbing and heating-air conditioning sales previously conducted on a divisional basis. **Charles W. Lovelace,** manager of the company's valve and fitting department, has been named to succeed Greene as director of industrial sales.

The appointment of four new vice presidents of The William Powell Co. has been recently announced. They are: **George W. Mueller, V. Anderson Coombe, John A. Parlin** and **Russell G. Smith.**

The Chase Brass & Copper Co. has announced two executive promotions effective June 1. **George Sengstacken,** works manager of the Chase Metal Works, has been named assistant vice president in charge of operations and is succeeded as works manager by **Gilbert R. Boutin,** former assistant works manager there.

Bailey Meter Co. has announced the election of two new officers and a new director. Factory manager **C. E. Sutherland** has been elected a vice president in charge of manufacturing; auditor **E. O. Stern** has been elected treasurer and assistant secretary; and vice president **H. H. Gorrie** has been elected to the board of directors.

The elections of **S. N. Fiala** as vice president and chief engineer and **Paul W. Emler** as assistant vice president were announced recently by American Gas and Electric Service Corp

John C. Wallace has been named vice president of engineering for the Walworth Co. Mr. Wallace was formerly vice president and general manager of Hunt-Spiller Manufacturing Corp., Boston.

Chain Belt Co. recently announced the appointment of three new regional managers. They are: **J. B. Roberts,** Chain Belt's Eastern regional manager; **William Sivyer,** Midwest and Southern regional manager; and **H. F. Bergis,** Northwestern regional manager.

Appointment of **Richard C. Walsh** as manager of the company's new

A COMPLETE REFRACTORIES SERVICE . . .

for Steam Generation

Monolithic furnace linings of GREFCO plastic firebrick are economical and will provide long uninterrupted service. Three high quality mixes are available for various furnace conditions with a selection of well engineered refractory and high temperature alloy metal anchors for various combinations and thicknesses.

GREFCO plastics are manufactured at three strategically located plants in Pennsylvania, Missouri and Georgia. Stocks are maintained for prompt truck delivery at all company warehouses and dealers in principal cities.

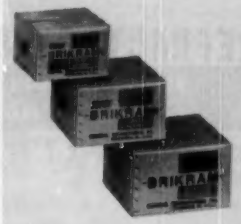
When you specify GREFCO you are assured of quality second to none. The world's finest and best equipped refractory laboratory is constantly developing new products and improving old ones. District laboratories constantly check raw materials and finished products. GREFCO places great emphasis on uniform high quality.

SUPER BRIKRAM MIX-G—a super duty quality plastic firebrick with a special binder which provides an airset when material is air dried. Provides high strength throughout the entire thickness of the wall or arch.

SUPER BRIKRAM—a plastic firebrick of super duty quality for furnace linings where conditions warrant the use of super duty quality. Has excellent resistance to spalling and high temperatures.

BRIKRAM—a plastic firebrick of high duty quality. Excellent for patching or complete furnace linings where conditions do not require a super duty quality refractory.

GENERAL REFRACTORIES CO.
Philadelphia 2, Pa.



GENERAL REFRACTORIES

Be Sure it's SUPER-FINISH Stic-Tite

The One-Coat Insulation

for Your Boilers • Tanks
Heaters • Fans • Ducts
Hot Walls • Uptakes
Breechings • Pipings • Fittings

✓ **Finishes Smooth in One Coat**

over insulating blankets, block, plastic insulating base or brick. No roughing coat needed.

✓ **Finishes Hard, White, Resistant**

to moisture or steam. Efficient—at all temperatures to 1700°F.

✓ **Stays on Permanently**

without shrinking, cracking or peeling. No pointing up or patching necessary. Adheres strongly to overhead, vertical or curved surfaces.

✓ **Goes a Long Way**

Super-Finish Stic-Tite has double the coverage of asbestos cement. Lowest cost coverage of any one-coat finish insulation.

✓ **Easy to Apply**

Simply mix dry finely ground pure white material with water and trowel—generally about ⅜" thick.

Try a 25-lb. bag of Super-Finish Stic-Tite.— No obligation

REFRACTORY & INSULATION CORP.

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

124 WALL STREET • NEW YORK 5, N. Y.

branch sales engineering office in Green Bay, Wisc., was recently announced by American Blower Division of American-Standard. Mr. Walsh will be responsible for providing sales engineering assistance to users of air handling, heating and air conditioning equipment, fluid drive power transmission units and refrigerating machines in the Green Bay area.

At the recently held annual meeting of the Chas. T. Main Co. the election of officers and directors took place. The officers are: **W. F. Uhl,** chairman of the board; **W. M. Hall,** president, **R. T. Colburn,** vice president; **R. W. Logan,** treasurer. The directors included **F. M. Gunby, R. W. Logan, W. F. Uhl, M. Jacobs, W. M. Hall, G. R. Rich,** and **R. T. Colburn.**

Ralph E. Van Kleeck has joined the firm of Day & Zimmermann, Inc. as a staff consulting engineer in connection with the management and operations of utilities and industrials. Mr. Van Kleeck is a former senior engineer with the Philadelphia Electric Co.

Appointments of **C. Knight Thigpen,** of Charleston, W. Va., and **Erwin F. Eckhardt,** of Pratt, W. Va., as managers of coal purchasing and coal mining, respectively, for the American Gas and Electric Service Corp., New York, has recently been announced. Both men assumed their new positions April 1, carrying out responsibilities previously held by **W. J. Rude,** coal manager for AGE, who is resigning June 1.

The Henry Pratt Co., Chicago, announced the promotion of **W. J. Woolley** to executive vice president. Mr. Woolley has been vice president in charge of sales since 1951, and has been instrumental in developing sales for Pratt's butterfly valves in water works and power plants.

E. P. Hansen has been promoted to assistant chief engineer of Allis-Chalmers steam turbine department succeeding **H. D. Emmert,** recently named chief engineer. **Cecil H. Morris** has been appointed engineer-in-chief of steam turbine design.

Vernon M. F. Tallman has been elected to the board of directors of Springfield Gas Light Co., Springfield, Mass. Mr. Tallman has been associated with the company since 1920 as engineer, commercial and industrial manager, executive assistant, consulting engineer, and vp.

The board of directors of Worthington Corp. announced recently the election of **Walther H. Feldmann** as president, succeeding **Edwin J. Schwanhausser,** who becomes vice-chairman. **Hobart C. Ramsey** will continue as chairman and chief executive officer.

DE LAVAL OPPELLER PUMPS

last longer... cut maintenance costs

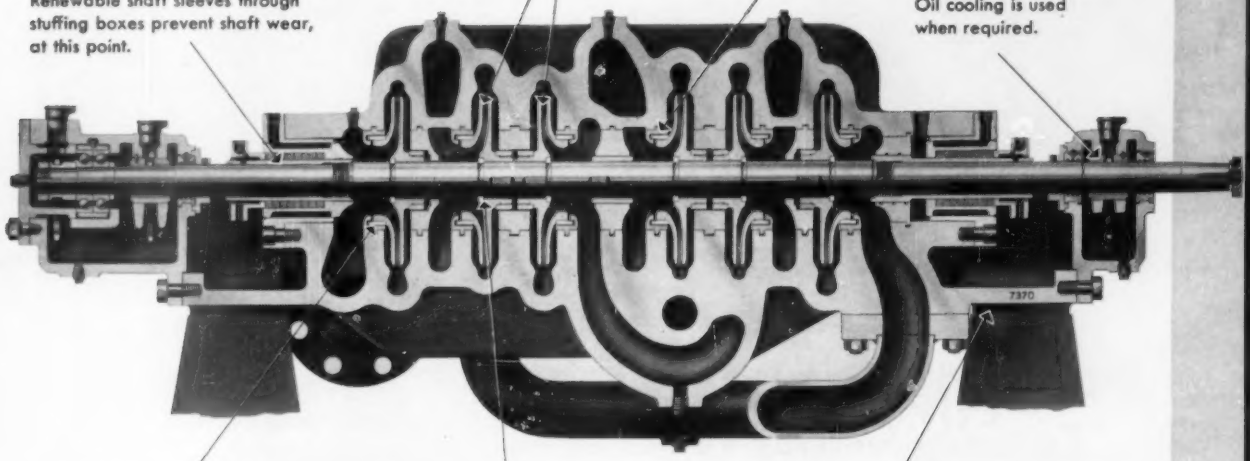
Stages are arranged to reduce differential pressures between stages. This insures permanent sealing at the casing-joint and at interstage diaphragms.

Pairs of back-to-back impellers balance axial thrust. One-purpose thrust bearing carries no radial load, maintains axial alignment.

Labyrinth wearing rings permit safe clearances and reduce wear.

All bearings are ring-oiled, sealed against contamination by water or dust. Oil cooling is used when required.

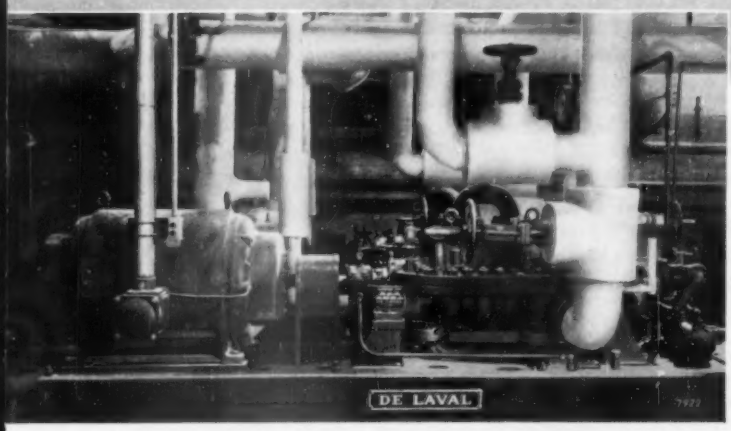
Renewable shaft sleeves through stuffing boxes prevent shaft wear, at this point.



Threaded impeller wearing rings make replacement easy without heating or damage to impellers.

Individual impeller mountings, with split locating rings, make interstage shaft sleeves unnecessary. Impellers can't shift with shaft expansion and contraction.

Casing support insures coupling alignment at any operating temperature.



Here are two De Laval 6-stage Oppeller Pumps used for boiler feed service in an industrial installation.

The design features above show clearly why De Laval Oppeller Pumps stay on the line longer and cost less to maintain. These pumps are used for boiler feed, hydraulic systems, descaling spray, mine dewatering, refinery oil pumping and similar services.

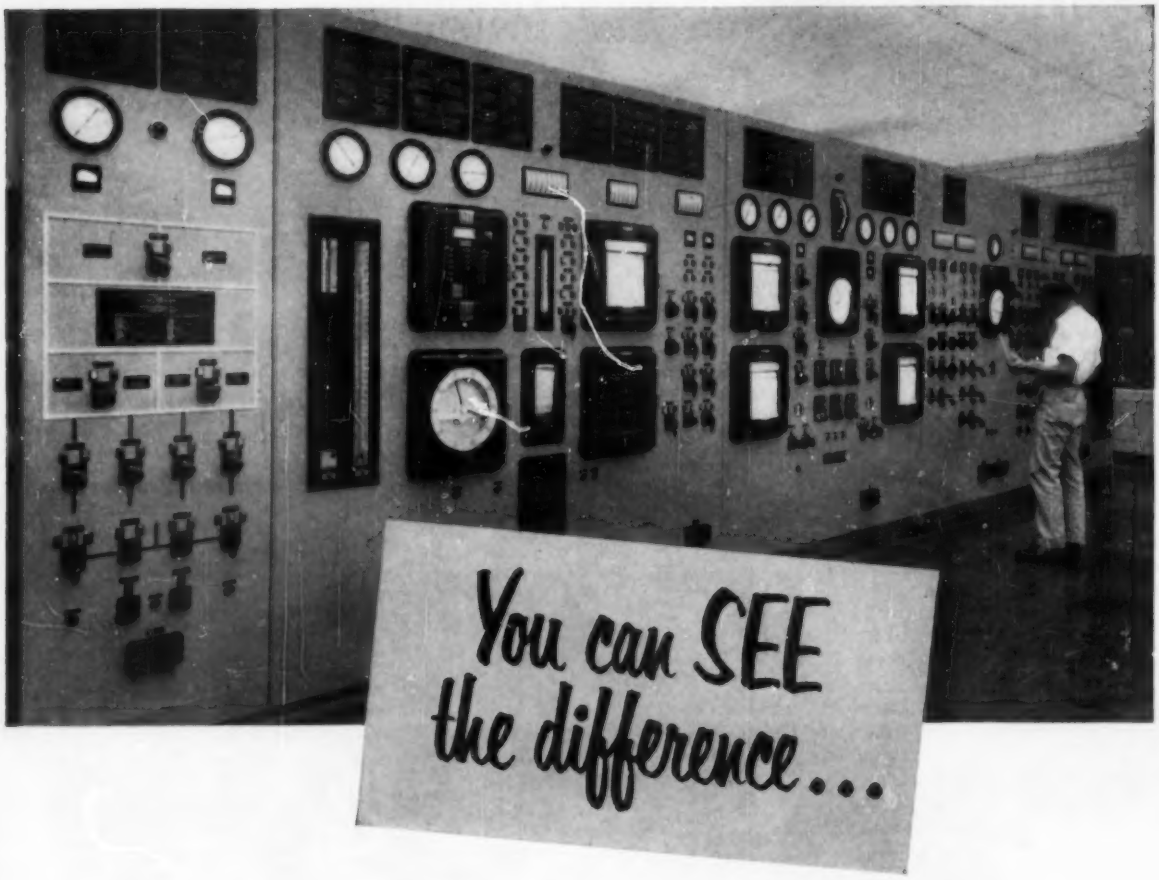
De Laval Oppeller Pumps are available in sizes from 2 to 4 inches and 2 to 8 stages; capacities to 1000 gpm, pressures to 1200 psig and temperatures to 350F.

DE LAVAL *Oppeller Pumps*

DE LAVAL STEAM TURBINE COMPANY

886 Nottingham Way, Trenton 2, New Jersey

DL286



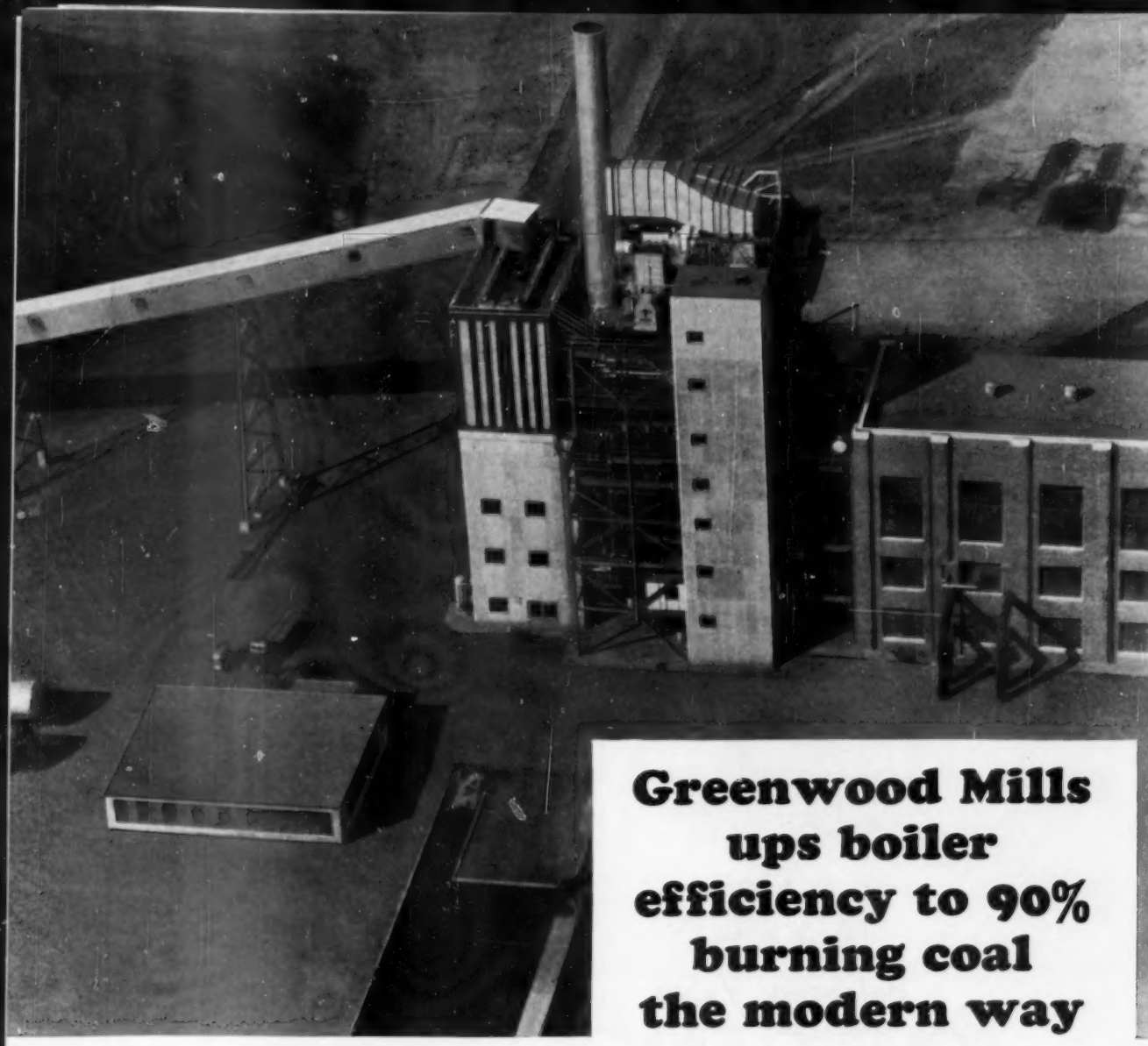
L+N complete panels serve the needs of your operating personnel. Each panel is designed and custom-built to your requirements. Instruments and controls are arranged in a functional pattern for easy reading . . . assist in reducing fuel costs and operating errors.

L+N complete panels save time and costs for your panel installation. We completely assemble each panel in our plant, with all instruments in place, double-checked and tested. You receive panels ready to go when connected to primary elements and control devices.

L+N complete panels solve your panel engineering and design problems. Our panel engineers convert your requirements for control of boiler, turbine and auxiliary equipment into a functional layout for your approval. From this layout we prepare the electrical and piping diagrams and the final steelwork drawings. You receive prints of these drawings as part of our standard panel engineering service.

***Let an L&N panel engineer** study your problems; he'll explain in detail what we can do for your particular plant. Our fifteen years in building panels for many utilities assures you of* effective service. *Write to Leeds & Northrup Company, 4972 Stenton Avenue, Philadelphia 44, Pa.*

LEEDS LN **NORTHRUP**
instruments *automatic controls • furnaces*



Greenwood Mills ups boiler efficiency to 90% burning coal the modern way

Consult an engineering firm

Designing and building hundreds of heating and power installations a year, qualified engineering firms can bring you the latest knowledge of fuel costs and equipment. If you are planning the construction of new heating or power facilities—or the remodeling of an existing installation—one of these concerns will work closely with your own engineering department to effect substantial savings not only in efficiency but in fuel economy over the years.

facts you should know about coal

In most industrial areas, bituminous coal is the lowest-cost fuel available • Up-to-date coal burning equipment can give you 10% to 40% more steam per dollar • Automatic coal and ash handling systems can cut your labor cost to a minimum. Coal is the safest fuel to store and use • No smoke or dust problems when coal is burned with modern equipment • Between America's vast coal reserves and mechanized coal production methods, you can count on coal being plentiful and its price remaining stable.

When its original power plant could not keep up with growing steam demand, Greenwood Mills, Greenwood, S. C., studied the problem and decided to replace the old facilities.

Greenwood's engineering and construction departments, working with Consulting Engineer Frank Hill of Greenville, designed and built a completely modern power plant. It features a pressurized 300,000 lb./hr. boiler equipped with two cyclone furnaces burning ¼" x 0" coal. Automatic throughout—from coal conveyors to pneumatic combustion control to hydraulic ash handling—the system is manned by a minimum of operators. Burning coal the modern way has resulted in a trouble-free boiler plant operating at a combustion efficiency of 90% or better.

For further information or additional case histories showing how other plants have saved money burning coal, write to the address below.

BITUMINOUS COAL INSTITUTE
Southern Building • Washington 5, D. C.

THE BAYER CO.

MANUFACTURERS OF BAYER SOOT BLOWERS

For Highest First and Final Value

. . . BUY BAYER!

BAYER

Balanced Valve

SOOT CLEANER

Bayer's single-chain design compels perfect in-step operation of valve and element. Operation is positive, definite, assuring a full flow of steam for efficient cleaning.

When the operator pulls chain, the cam-actuated, quick-action balanced valve is opened. By continued pulling of the chain, worm drive slowly rotates element over cleaning arc. When element reaches end of cleaning arc, valve automatically closes.

Minimum steam consumption—low maintenance. Every detail is engineered, built for long life, efficient performance at high temperatures and high pressures.

More than 30,000 boilers are Bayer equipped. More than 45 years' successful, specialized experience assures you investment economies in Bayer equipment.

QUALIFIED LOCAL ENGINEERING SERVICE—Your Bayer representative is an experienced engineer, well qualified to take care of any service needs in connection with Bayer Soot Cleaners. He is available when you call upon him and will gladly render any service required.

All These Mechanical and Operating Advantages are available in

The BAYER *Balanced Valve* SOOT CLEANER

1. **Sound engineering, workmanship, and materials of the best.**
2. **An organization of over 45 years' experience, capable and willing to render service at all times.**

SINGLE CHAIN: Valve and element controlled by a single chain.

VALVE BODY: Rugged construction, built to last. Short and ample steam passage giving very small pressure drop.

ORIFICE PLATE VALVE: For high pressure service, each head may be controlled by an orifice plate valve through which pressure is adjusted for each individual element.

STUFFING BOX: Due to maintenance of perfect alignment on swivel tube, packing needs little attention. Stuffing box is in full view, readily accessible.

AIR SEAL: Has machined surface on wall sleeve and spring-held floating seal to prevent air in-leakage.

HEAD BEARINGS: There are two main bearings, an outboard and an inboard bearing for the swivel tube to maintain alignment.

THRUST BEARING: Ring type thrust bearing takes the load.

VACUUM BREAKERS: Two vacuum breaker air valves, or one valve and a signal whistle above each valve, to prevent suction of boiler gases into valve and piping.

ELEMENT OPERATION: With the Bayer element operation, balanced valve is opened just as element rotates, giving FULL pressure over entire cleaning arc. Full steam pressure insures thorough cleaning. Balanced valve saves wear of valve parts. With any type of poppet valve, this is important. . . ask any operator.

BLOWING ARC: Valve cams automatically regulate cleaning arc.

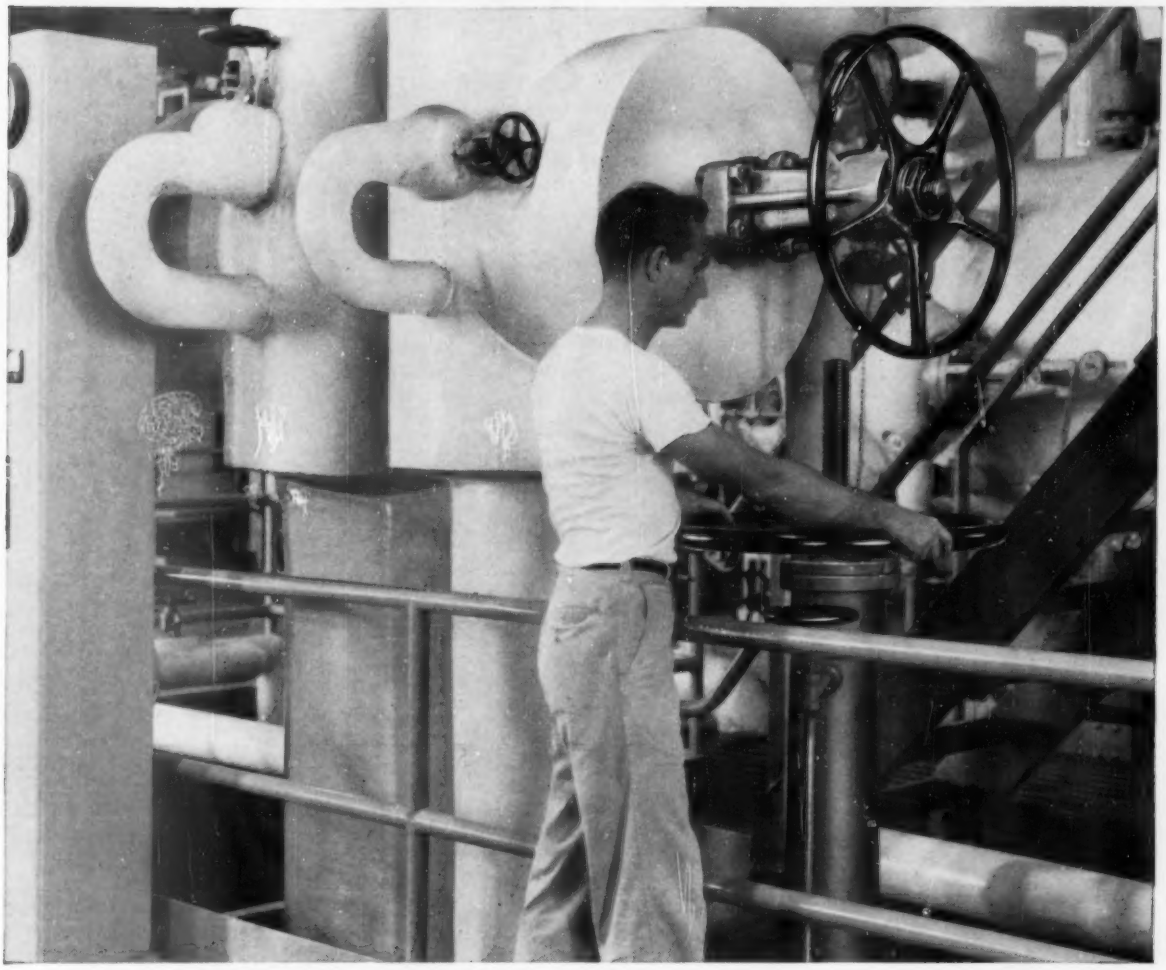
REDUCTION GEARS: 24 to 1 gear ratio gives slow rotation for good cleaning.

FLANGED PIPE CONNECTION: Operating head is connected to supply pipe by flanges and through bolts, or high tensile studs and nuts.

THE BAYER CO.

St. Louis, Mo.

How Crane Steel Valves Cut Power Piping Costs



Everything's O.K. below—since 1942

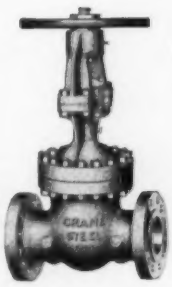
Always smooth, always positive in action—says the operator of this Crane 10-inch, 600-pound steel gate valve with extension yoke . . . and never a sign of leakage at the seats or bonnet joint.

That's the way this valve has performed for 15 years—since it was installed in a main steam cross-over line in the Nueces Bay Station of Central Power & Light in Corpus Christi. It's on working pressure of 400 psi at 830 deg. F.

The cost-in-service record of the valve is clean. It has not been touched by a mechanic except for ordinary routine servicing. Indications are it will remain in the line for a long time to come.

Unusual performance? Not for Crane steel valves. They're famous for cutting power piping costs. They're better suited for such service because of quality castings made in Crane's own foundry—with closely controlled heat-treating techniques . . . exacting machining, assembling and testing procedures that are unique with Crane.

You can be sure of low-cost steel valve performance when you specify Crane. Get all the facts from your Crane Representative or write to the address below.



CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches and Wholesalers in All Areas

Quality Control on Job Site is important too

In the prefabricating of critical piping in our plant, radiographic inspection, ultrasonic testing and magnetic-particle examination are routine precautions. That they are available in the field is to be expected of Mitchell's distinguished service to power and processing plants. For full satisfaction and economy, next time ask us in.

W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

General and Classified Index

COMBUSTION, Volume Twenty-Eight, July 1956 Through June 1957

EDITORIALS

		Page
America's Next Twenty Years	May 1957	37
Arithmetic and the Atom	Apr. 1957	33
Coal Markets in Florida?	Mar. 1957	33
Feeding the Thirst for Knowledge	Nov. 1956	39
Graduation Day—Planned and Plotted	June 1957	34
Helping Those Who Help Themselves	Aug. 1956	33
Hopeful View of the Atom, A	Nov. 1956	39
It Couldn't Be Done	Mar. 1957	33
Maintenance Costs and Their Control	Jan. 1957	33
National Science Youth Day	Feb. 1957	33
One Way to Arouse Action	Oct. 1956	35
Opportunity for Authors, An	Aug. 1956	33
Optimizing Power Plant Components	July 1956	37
Power Engineering Behind the Iron Curtain	Sept. 1956	41
Progress in the Making	July 1956	37
Pure Research and Its Rewards	Sept. 1956	41
Putting a Shoulder to the Wheel	May 1957	37
Recognition of Engineering Specialties	Feb. 1957	33
Tackling the Flyash Problem	Oct. 1956	35
We Say, "Amen"	Dec. 1956	37
What Price Individuality?	Jan. 1957	33

AUTHORS

		Page
Aebersold, A. F., and A. B. Wilder—*Yesterday, Today and Tomorrow—Pipeline Steels*, ASME Annual	Dec. 1956	55
Alquist, F. N., and A. M. Guy—*Non-Destructive Thickness Measurements of Boiler Deposits*, Annual Water Conf.	Nov. 1956	67
Anderson, D. R., and W. R. Watson—*Soot Ignition Temperature Measurement*	Oct. 1956	43
Anderson, John F., Weymouth N. McDaniel, and Charles M. Heidel—*Enrico Fermi Atomic Power Plant*, ASME Annual Meeting	Dec. 1956	52
Andres, R. F.—*Evaporated Makeup Water for a Monotube Boiler*, ASME Annual Meeting	Jan. 1957	48
Angele, Gustave J., Gordon W. Brush, and S. B. Applebaum—*Mixed-Bed Demineralizer Operations at AEC Facilities, Oak Ridge, Tenn.*, Annual Water Conf.	Nov. 1956	65
Antonsen, A. K.—*The Development of Supercharged Medium-Speed, Two-Cycle Opposed Piston Engine*, ASME Annual Meeting	Dec. 1956	56
Applebaum, S. B., Gordon W. Brush and Gustave J. Angele—*Mixed-Bed Demineralizer Operations at AEC Facilities, Oak Ridge, Tenn.*, Annual Water Conf.	Nov. 1956	65
Applebaum, S. B., and R. J. Zumbrunnen—*Selecting Water-Treating Processes for Medium-Pressure Boilers*, ASME Annual Meeting	Jan. 1957	48
Applebaum, S. B., and B. E. Varon—*An Application of Hot-Lime Zeolite to Moderate High-Pressure Boiler Operations*, American Power Conf.	Apr. 1957	47
Archbold, M. J.—*Dust Collectors for Central Station Steam Power Plants*	Aug. 1956	34
Arnoff, Dr. E. Leonard, and John C. Chambers—*Operations Research Determination of Generation Reserves*, AIEE Winter General Meeting	Feb. 1957	63
Arnow, S. M.—*Eddystone Supercritical Heat Cycle Incorporates Stack Gas Heat*	Apr. 1957	34
Attwill, W. H., C. D. Day, Jr. and A. J. Johnson—*Evaluating Coal by Utilization Cost*, ASME Annual Meeting	Dec. 1956	57
Baggish, P. F.—*What Do Modern High-Pressure Boilers Demand of Feedwater?*, ASME Annual Meeting	Jan. 1957	47
Baker, M. D.—*Three Years Experience with Hydrazine*, American Power Conf.	Apr. 1957	48
Baker, M. L., H. C. Hottel, and G. C. Williams—*Combustion Studies in a Stirred Reactor*, Sixth International Combustion Symposium	Sept. 1956	73
Barker, Joseph W.—*Research—The Window of Tomorrow*, BCR Techno-Sales Conf.	May 1957	65
Baumeister, Theodore—*A Power Engineer Looks Ahead Ten Years*	May 1957	53
Benedict, Manson, and Thomas H. Pigford—*Fuel Cycles in Single-Region Thermal Reactors*, 1957 Nuclear Congress	Mar. 1957	62
Berk, A. A.—*Use of the Bureau of Mines Condensate-Corrosion Tester for the Survey of Return-Line Deterioration*, ASME Annual Meeting	Jan. 1957	49
Berry, B. C.—*A Case History of Automatic Ash and Dust Handling Progress*	June 1957	45
Binns, J. E., W. Lones, D. G. Pitcher and M. Melice—*Safety Circuit Development at Brookhaven National Laboratory*, 1957 Nuclear Congress	Mar. 1957	64
Bishof, C. A., J. K. Brown and H. L. Kahler—*Conductivity Versus Sodium by Flame Spectrophotometer in Steam-Purity Studies*, ASME Annual Meeting	Jan. 1957	48
Blaskowski, Henry J., and Joseph G. Singer—*Gas Turbine Boiler Applications*	May 1957	38
Blumberg, H. S.—*Metallurgical Considerations of Main Steam Piping for High-Temperature, High-Pressure Service*, ASME Annual Meeting	Jan. 1957	49
Boobyer, E. F., and E. R. Lee, Jr.—*Industrial Power Plant Developments*	Mar. 1957	45
Brewster, Harold M.—*Development of an Explosive Gas-Air Mixture Detector*, Sixth International Combustion Symposium	Oct. 1956	65
Broadley, Peter R., and W. M. Meyer—*Coal-Fired Gas Turbine*, BCR Techno-Sales Conf.	May 1957	65
Brooks, Aaron D.—*Precision Valve Point Loading of Turbines Using a Digital Computer Saves Dollars*, American Power Conf.	May 1957	62
Brown, J. K., C. A. Bishof and H. L. Kahler—*Conductivity Versus Sodium by Flame Spectrophotometer in Steam-Purity Studies*, ASME Annual Meeting	Jan. 1957	48
Brush, Gordon W., S. B. Applebaum and Gustave J. Angele—*Mixed-Bed Demineralizer Operations at AEC Facilities, Oak Ridge, Tenn.*, Annual Water Conf.	Nov. 1956	65
Bulgakova, N. V., K. A. Rakov, L. B. Krol and M. D. Panasenko—*Experimental Boiler Plant with Once-Through Boiler for Steam Conditions up to 4266 Psia, 1112 F*	Sept. 1956	42
Burgess, David S., J. Kenneth Richmond, Joseph M. Singer, E. B. Cook, James R. Oxendine and Joseph Grumer—*Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence*, Sixth International Combustion Symposium	Sept. 1956	77
Burstadt, E. W., D. E. Hart, L. J. Marshall and H. R. Shannon—*Liquid Metal in a Double-Reheat, Fuel-Fired Steam Plant*	Jan. 1957	53
Cadwallader, L. W.—*Problems Related to the Location of Generating Plants, Transmission Facilities and Substations*	July 1956	45
Cameron, D. H., and E. L. Mueller—*Economic Aspects of the General Electric Automatic Dispatching System at Kansas City*, AIEE Winter General Meeting	Feb. 1957	65
Campbell, C. B., C. C. Franck, Sr. and J. C. Spahr—*The Eddystone Superpressure Unit*, ASME Annual Meeting	Jan. 1957	46
Chambers, John C., and Dr. E. Leonard Arnoff—*Operations Research Determination of Generation Reserves*, AIEE Winter General Meeting	Feb. 1957	63
Coffin, L. F., Jr.—*An Investigation of Thermal Stress Fatigue as Related to High-Temperature Piping Flexibility*, ASME Annual Meeting	Dec. 1956	56
Cohen, Paul—*Nuclear Water Technology*, Annual Water Conf.	Nov. 1956	64
Coleman, Paul H.—*Automation of Water Treating Equipment*, Annual Water Conf.	Nov. 1956	63
Cook, E. B., J. Kenneth Richmond, Joseph M. Singer, James B. Oxendine, Joseph Grumer and David S. Burgess—*Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence*, Sixth International Combustion Symposium	Sept. 1956	77
Corey, R. C.—*Measurement of Gas Temperatures with Thermocouples*	Oct. 1956	47
Coulter, S. B., R. L. Jackson and R. Sheppard—*Importance of Matching Steam Temperatures with Metal Temperatures During Starting of Large Steam Turbines*, ASME Annual Meeting	Jan. 1957	51
Creagan, Robert J., Glenn A. Reed and Walter C. Woodman—*The Yankee Atomic Electric Plant*, ASME Annual Meeting	Dec. 1956	51
Crofts, F. S.—*Panel Construction Invades Medium Boiler Field*	Jan. 1957	41
Curran, R. M., and A. W. Rankin—*Austenitic Steels in High-Temperature Steam Piping*, ASME Annual Meeting	Jan. 1957	49
Daman, Ernest L., and E. L. Richardson—*Economics of Medium-Sized Supercharged Power Plants*, American Power Conf.	Apr. 1957	46
Dauber, C. A.—*Avon No. 8—A Supercritical Pressure Plant*	Aug. 1956	47
—*Pipeline Transportation of Coal*	Apr. 1957	39
David, M. M., and R. F. Peak—*Costs of Cation Exchange Equipment*	May 1957	48
Davis, Hunt—*Equivalent Performance Parameters for Turboblowers and Compressors*, ASME Annual Meeting	Dec. 1956	58
Day, C. D., Jr., W. H. Attwill and A. J. Johnson—*Evaluating Coal by Utilization Cost*, ASME Annual Meeting	Dec. 1956	57
Decker, Gerald L.—*Incremental Efficiency Testing of Industrial Turbine-Generators to Determine Valve Points, Saves Kilowatts*, American Power Conf.	May 1957	62
Deckers, J., and A. Van Tiggelen—*Chain Branching and Flame Propagation*, Sixth International Combustio.. Symposium	Sept. 1956	76

Page

Del'Homme, L. K.—*Outdoor Versus Indoor Steam-Electric Stations in the Houston Area*.....Sept. 1956 55
Dick, I. B.— *The Performance of the Demineralizer in the Preparation of High Quality Water*, ASME Annual Meeting.....Jan. 1957 47
Dittrich, R. T., and J. S. Grobman—*Pressure Drop and Air Flow Distribution in Gas-Turbine Combustors*, ASME Annual Meeting.....Dec. 1956 58
Downs, J. E., and C. W. Elston—*Future of the Steam Turbine Cycle*, American Power Conf.....May 1957 60
Dreyer, Walter—*Integrating Steam and Hydro Power in Northern and Central California*, American Power Conf.....May 1957 63
Duff, J. H., and Robert Dvorin—*Anion Exchange Subfill as a Factor in Demineralizer Rinse Requirements*, American Power Conf.....Apr. 1957 48
Edlund, Milton C.—*Liquid Metal Fueled Reactor*, Atomic Industrial Forum Conf.....Nov. 1956 71
Edwards, T. W., and Igor J. Karassik—*Progress Report on High-Speed Boiler Feed Pumps*, American Power Conf.....May 1957 61
Elliott, O. M.—*The History of Ion Exchange and Some Interesting Recent Developments*.....July 1956 57
Elliott, V. A., J. R. Wolcott, E. P. Peabody, G. M. Roy, J. L. Schanz and G. Sege—*The Dresden Nuclear Station*, ASME Annual Meeting.....Dec. 1956 51
Elston, C. W., and J. E. Downs—*Future of the Steam Turbine Cycle*, American Power Conf.....May 1957 60
Ezekiel, F. D., and J. L. Shearer—*Pressure-Flow Characteristics of Pneumatic Valves*, ASME Annual Meeting.....Dec. 1956 56
Fadden, W. J., Jr., and H. A. Kuljian—*A New Way to Simplify the Steam Power Plant*.....July 1956 51
Fairchild, F. P.—*Eight Years of Experience with Austenitic-Steel Piping Materials at Elevated Steam Conditions*, ASME Annual Meeting.....Dec. 1956 54
Fax, D. H., W. E. Johnson and S. C. Townsend—*The PAR Homogeneous Reactor Project*, ASME Annual Meeting.....Dec. 1956 54
Fourê, G., and G. Matton—*Thermoelectric Probes for Measuring High Temperatures in Gas Streams: Their Application to the Study of Flames Stabilized by Obstacles*, Sixth International Combustion Symposium..Oct. 1956 62
Franck, C. C., Sr., C. B. Campbell and J. C. Spahr—*The Eddystone Superpressure Unit*, ASME Annual Meeting.....Jan. 1957 46
Friston, R. M.—*The Structure of Laminar Flame Fronts*, Sixth International Combustion Symposium.....Oct. 1956 61
Garvey, James R.—*The Current BCR Program*, BCR Techno-Sales Conf.....May 1957 66
Gatewood, Arthur R., and Capt. Charles P. Murphy—*Development of Safety Standards for Nuclear Propulsion*, 1957 Nuclear Congress.....Mar. 1957 63
Gerber, R. C., F. C. Gronemeyer, H. M. Hagaman, H. B. Holz, H. A. Ross-Clunis and E. F. Weisner—*Proposed 75,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska*, ASME Annual Meeting.....Dec. 1956 53
Grasme, P.—*State of Slagging Furnace Development in Germany*.....Feb. 1957 34
Greten, Warren A., and Robert T. Hess—*Recent Application Results of the Hydrazine-Sodium Sulfite Combination*, American Power Conf.....Apr. 1957 48
Grobman, J. S., and R. T. Dittrich—*Pressure Drop and Air Flow Distribution in Gas-Turbine Combustors*, ASME Annual Meeting.....Dec. 1956 58
Gronemeyer, F. C., R. C. Gerber, H. M. Hagaman, H. B. Holz, H. A. Ross-Clunis and E. F. Weisner—*Proposed 75,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska*, ASME Annual Meeting.....Dec. 1956 53
Grumer, Joseph, J. Kenneth Richmond, Joseph M. Singer, E. B. Cook, James R. Oxendine and David S. Burgess—*Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence*, Sixth International Combustion Symposium.....Sept. 1956 77
Guy, A. M., and F. N. Alquist—*Non-Destructive Thickness Measurements of Boiler Deposits*, Annual Water Conf.....Nov. 1956 67
Hagaman, H. M., F. C. Gronemeyer, R. C. Gerber, H. B. Holz, H. A. Ross-Clunis and E. F. Weisner—*Proposed 75,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska*, ASME Annual Meeting.....Dec. 1956 53
Hannula, Fred W.—*The BTU Computer—An Advanced Data System for Industry*, AIEE Winter General Meeting.....Feb. 1957 62
Harden, J. E., and Glenn R. Hull—*Operating Experiences with a Large Hot-Lime Zeolite System for 1500-psi Boilers*, American Power Conf.....Apr. 1957 47
Harlow, James H.—*Projecting Steam Costs to 1980*.....June 1957 41
Hart, D. E., E. W. Burstadt, L. J. Marshall and H. R. Shannon—*Liquid Metal in a Double-Reheat, Fuel-Fired Steam Plant*.....Jan. 1957 53
Harward, E. D., E. C. Tsivoglou and W. Marcus Ingram —*Steam Surveys for Radioactive Waste Control*, 1957 Nuclear Congress.....Mar. 1957 64
Healy, J. W.—*Influence of the National Academy of Science's Report on the Nuclear Power Industry*, Atomic Industrial Forum Conf.....Nov. 1956 75

Page

Heidel, Charles M., John F. Anderson and Wymouth N. McDaniel—*Enrico Fermi Atomic Power Plant*, ASME Annual Meeting.....Dec. 1956 52
Hess, Robert T., and Warren A. Greten—*Recent Application Results of the Hydrazine-Sodium Combination*, American Power Conf.....Apr. 1957 48
Holz, H. B.—*Proposed 75,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska*, ASME Annual Meeting.....Dec. 1956 53
Hornschuch, H.—*Boiler Feed Pumps for 6500-Psi Discharge Pressure*, American Power Conf.....May 1957 61
Hottel, H. C., G. C. Williams and M. L. Baker—*Combustion Studies in a Stirred Reactor*, Sixth International Combustion Symposium.....Sept. 1956 73
Hull, Glenn, and J. E. Harden—*Operating Experiences with a Large Hot-Lime Zeolite System for 1500-psi Boilers*, American Power Conf.....Apr. 1957 47
Huntington, R. L., and D. P. Sobocinski—*Concurrent Flow of Air, Gas-Oil, and Water in a Horizontal Pipe*, ASME Annual Meeting.....Jan. 1957 50
Hupfer, H. J., R. J. Stanley and A. H. Van Sickle—*In-Service Washing of Ljungstrom Air Preheaters on Pulverized-Coal-Fired Steam Generators*, ASME Annual Meeting.....Jan. 1957 51
Igoe, John W.—*Potential for the Coal-Burning Gas Turbine*, BCR Techno-Sales Conf.....May 1957 65
Ingram, W. Marcus, E. C. Tsivoglou and E. D. Harward—*Stream Surveys for Radioactive Waste Control*, 1957 Nuclear Congress.....Mar. 1957 64
Jackson, R. L., S. B. Coulter and R. Sheppard—*Importance of Matching Steam Temperatures with Metal Temperatures During Starting of Large Steam Turbines*, ASME Annual Meeting.....Jan. 1957 51
Jarvis, Theodore—*The Gas Turbine Reactor*, Atomic Industrial Forum Conf.....Nov. 1956 73
Johnson, A. J., W. H. Attwill and C. D. Day, Jr.—*Evaluating Coal by Utilization Cost*, ASME Annual Meeting.....Dec. 1956 57
Johnson, W. E., D. H. Fax and S. C. Townsend—*The PAR Homogeneous Reactor Project*, ASME Annual Meeting.....Dec. 1956 54
Kahler, H. Lewis, C. A. Bishof and J. K. Brown—*Conductivity Versus Sodium by Flame Spectrophotometer in Steam-Purity Studies*, ASME Annual Meeting....Jan. 1957 48
Kallen, Howard P.—*Distribution of Steam and Electrical Power Costs in an Industrial Plant*, American Power Conf.....May 1957 62
Kanter, J. J.—*On the Quality Requirements for Steel Valves for Nuclear Power Plants*, 1957 Nuclear Congress.....Mar. 1957 60
Karassik, Igor J., and T. W. Edwards—*Progress Report on High-Speed Boiler Feed Pumps*, American Power Conf.....May 1957 61
Kattus, T. R.—*Properties of Cast Iron at Elevated Temperatures—A Progress Report*.....June 1957 49
Katz, William—*The Present Status of Electric Membrane Demineralization*, Annual Water Conf.....Nov. 1956 67
Keagy, W. R., Jr., and Harlan W. Nelson—*The Economic Background for the Competitive Development of Nuclear Power*, 1957 Nuclear Congress.....Mar. 1957 59
Kittridge, C. P., and D. S. Rowley—*Resistance Coefficients for Laminar and Turbulent Flow Through One-Half Inch Valves and Fittings*, ASME Annual Meeting.....Dec. 1956 55
Kotelewskij, George P.—*Bubble Contact Heaters for Power Plants*.....Sept. 1956 67
Krol, L. B., K. A. Rakov, M. D. Panasenko and N. V. Bulgakova—*Experimental Boiler Plant with Once-Through Boiler for Steam Conditions up to 4266 Psia, 1112 F*.....Sept. 1956 42
Kuljian, H. A., and W. J. Fadden, Jr.—*A New Way to Simplify the Steam Power Plant*.....July 1956 51
LeBailly, A. R., and L. Skog, Jr.—*Design and Characteristics of a Combined Gas and Steam Cycle of 40,000-Kw Capacity*, American Power Conf.....Apr. 1957 44
Lee, E. R., Jr., and E. F. Boobyer—*Industrial Power Plant Developments*.....Mar. 1957 45
Lees, B.—*An Investigation into the Air-Heater Corrosion of Oil-Fired Boilers*.....July 1956 38
LeVesconte, L. B.—*Economics of Replacement of Generator Capacity*, American Power Conf.....Apr. 1956 67
Lewin, Perez Otis—*Heat Balance Studies in Textile Plants*.....Feb. 1957 47
Linnett, J. W., and C. J. S. Simpson—*Limits of Inflammability*, Sixth International Combustion SymposiumOct. 1956 67
Lones, W., J. E. Binns, D. G. Pitcher and M. Melice—*Safety Circuit Development at Brookhaven National Laboratory*, 1957 Nuclear Congress.....Mar. 1957 64
Losee, L. B.—*Experiences with the Turner Scale Thickness Indicator*, Annual Water Conf.....Nov. 1956 67
Louzecky, P. J.—*Design and Development of a Two-Cycle Turbocharged Diesel Engine*, ASME Annual Meeting Dec. 1956 57
Lundgren, C. E., and C. Seippel—*Thermal Problems of Atomic Power Stations—I*.....Feb. 1957 51
—II.....June 1957 51
McCullough, C. Rogers—*Reactor Safety: Round Table Sponsored by Nuclear Energy Writers Assoc.*, Atomic Industrial Forum Conf.....Nov. 1956 75
McDaniel, Weymouth N., John F. Anderson and Charles M. Heidel—*Enrico Fermi Atomic Power Plant*, ASME Annual Meeting.....Dec. 1956 52

Page

McGann, Paul W.—*Competition, Substitution and Demand Among Fuels*, ASME Annual Meeting....Dec. 1956 57
McMahon, Earl C., and Wallace W. Maull—*Fly Ash Refiring*....Nov. 1956 40
Manjoine, M. J.—*Creep Characteristics of Type 347 Stainless Steel, at 1050 and 1100 F in Tension and Compression*, ASME Annual Meeting....Dec. 1956 56
Marshall, L. J., E. W. Burstadt, D. E. Hart and H. R. Shannon—*Liquid Metal in a Double-Reheat, Fuel-Fired Steam Plant*....Jan. 1957 53
Martin, Ronald J.—*Allocating Heat Energy in an Industrial Plant*....Apr. 1957 49
Matton, G., and C. Fourê—*Thermoelectric Probes for Measuring High Temperatures in Gas Streams: Their Application to the Study of Flames Stabilized by Obstacles*, Sixth International Combustion Symposium..Oct. 1956 62
Maull, Wallace W., and Earl C. McMahon—*Fly Ash Refiring*....Nov. 1956 40
Melice, M., J. E. Binns, W. Lones and D. G. Pitcher—*Safety Circuit Development at Brookhaven National Laboratory*, 1957 Nuclear Congress....Mar. 1957 64
Meyer, W. M., and P. R. Broadley—*Coal-Fired Gas Turbine*, BCR Techno-Sales Conf....May 1957 65
Milne, G. R., and F. R. Ward—*The Consolidated Edison Indian Point Nuclear Power Plant*, ASME Annual Meeting....Dec. 1956 53
Monroe, H., Jr., and W. A. Sherbrooke—*Air and Gas Duct System for the Gas-Turbine Vessel "John Sergeant,"* ASME Annual Meeting....Dec. 1956 58
Monroe, Robert A.—*Some Factors in the Economic Generation of Power by the TVA System*, American Power Conf....May 1957 63
Moore, W. T.—*Economics of Pressurized-Water Reactors Fueled with Uranium-235 and Thorium*, Atomic Industrial Forum Conf....Nov. 1956 70
Mott, Willard S.—*The Sodium Deuterium Reactor*, Atomic Industrial Forum Conf....Nov. 1956 74
Mueller, E. L., and D. H. Cameron—*A New Type Automatic Dispatching System at Kansas City*, ASME Annual Meeting....Dec. 1956 59
—*Economic Aspects of the General Electric Automatic Dispatching System at Kansas City*, AIEE Winter General Meeting....Feb. 1957 65
Murphy, Charles P., and Arthur R. Gatewood—*Development of Safety Standards for Nuclear Propulsion of Merchant Ships*, 1957 Nuclear Congress....Mar. 1957 63
Neat, Frank U.—*Inspection of Non-Magnetic Tubing in Corrosive Service by the Probolog Method*, Annual Water Conf....Nov. 1956 66
Nelson, H. W., and W. R. Keagy, Jr.—*The Economic Background for the Competitive Development of Nuclear Power*, 1957 Nuclear Congress....Mar. 1957 59
Oxendine, James R., J. Kenneth Richmond, Joseph M. Singer, E. B. Cook, Joseph Grumer and David S. Burgess—*Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence*, Sixth International Combustion Symposium....Sept. 1956 77
Panasenko, M. D., K. A. Rakov, L. B. Krol and N. V. Bulgakova—*Experimental Boiler Plant with Once-Through Boiler for Steam Conditions up to 4266 Psia, 1112 F*....Sept. 1956 42
Patterson, M. M., E. V. Pollard and W. B. Wilson—*Economics of Higher Pressures and Temperatures for Steam Turbines in Industrial Plants*, American Power Conf....May 1957 60
Peabody, E. P., G. M. Roy, J. L. Schanz and G. Sege—*The Dresden Nuclear Station*, ASME Annual MeetingDec. 1956 51
Peak, R. F., and M. M. David—*Costs of Cation Exchange Equipment*....May 1957 48
Pigford, Thomas H., and Manson Benedict—*Fuel Cycles in Single-Region Thermal Reactors*, 1957 Nuclear Congress....Mar. 1957 62
Pirsh, E. A., and F. G. Raynor—*Instrumentation for the Determination of Steam Purity*, Annual Water Conf...Nov. 1956 65
Pitcher, D. G., J. E. Binns, W. Lones and M. Melice—*Safety Circuit Development at Brookhaven National Laboratory*, 1957 Nuclear Congress....Mar. 1957 64
Pollard, E. V., M. M. Patterson and W. B. Wilson—*Economics of Higher Pressures and Temperatures for Steam Turbines in Industrial Plants*, American Power Conf....May 1957 60
Pollock, W. A.—*Aluminum Condenser Tubes, A Report on a Plant Installation*, American Power Conf....May 1957 59
Popov, V. A.—*Method of Measuring the Temperature of Burning Fuel Particles in Motion*, Sixth International Combustion Symposium....Oct. 1956 62
Powell, E. M.—*Operating Experiences with Twin Furnace Boilers*, American Power Conf....Apr. 1957 47
Profos, Dr. P.—*Dynamics of Pressure and Combustion Control in Steam Generators*....Mar. 1957 34
Prohl, M. A.—*A Method for Calculating Vibration Frequency and Stress of a Banded Group of Turbine Buckets*, ASME Annual Meeting....Jan. 1957 50
Prohl, M. A., and F. L. Weaver—*High-Frequency Vibration of Steam-Turbine Buckets*, ASME Annual Meeting....Jan. 1957 50
Rae, John B.—*The Engineer and the American Economy*....Feb. 1957 61
Rakov, K. A., L. B. Krol, M. D. Panasenko and N. V. Bulgakova—*Experimental Boiler Plant with Once-Through Boiler for Steam Conditions up to 4266 Psia, 1112 F*....Sept. 1956 42
Rankin, A. W., and R. M. Curran—*Austenitic Steels in High-Temperature Steam Piping*, ASME Annual Meeting....Jan. 1957 49
Raynor, F. G., and E. A. Pirsh—*Instrumentation for the Determination of Steam Purity*, Annual Water Conf...Nov. 1956 65
Reed, Glenn A., Robert J. Creagan and Walter C. Woodman—*The Yankee Atomic Electric Plant*, ASME Annual Meeting....Dec. 1956 51
Rice, J. K—*Quality Measurements by Flame Photometer*....Nov. 1956 57
Richardson, E. L., and E. L. Daman—*Economics of Medium-Sized Supercharged Power Plants*, American Power Conf....Apr. 1957 46
Richmond, J. Kenneth, Joseph M. Singer, E. B. Cook, James R. Oxendine, Joseph Grumer and David S. Burgess—*Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence*, Sixth International Combustion Symposium....Sept. 1956 73
Roberts, H. E.—*Steam Power Plant Maintenance Costs*...Dec. 1956 38
Ross-Clunis, H. A., F. C. Gronemeyer, R. C. Gerber, H. M. Hagaman, H. B. Holz and E. F. Weisner—*Proposed 75,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska*, ASME Annual Meeting....Dec. 1956 53
Rowley, D. S., and C. P. Kittridge—*Resistance Coefficients for Laminar and Turbulent Flow Through One-Half Inch Valves and Fittings*, ASME Annual Meeting....Dec. 1956 55
Roy, G. M., J. R. Wolcott, V. A. Elliott, E. P. Peabody, J. L. Schanz and G. Sege—*The Dresden Nuclear Station*, ASME Annual Meeting....Dec. 1956 51
Schanz, J. L., J. R. Wolcott, V. A. Elliott, E. P. Peabody, G. M. Roy and G. Sege—*The Dresden Nuclear Station*, ASME Annual Meeting....Dec. 1956 51
Sege, G., J. W. Wolcott, V. A. Elliott, E. P. Peabody, G. M. Roy and J. S. Schanz—*The Dresden Nuclear Station*, ASME Annual Meeting....Dec. 1956 51
Seippel, C., and C. E. Lundgren—*Thermal Problems of Atomic Power Stations*—I....Feb. 1957 51
—II....June 1957 51
Shannon, H. R., E. W. Burstadt, D. E. Hart, and L. J. Marshall—*Liquid Metal in a Double-Reheat, Fuel-Fired Steam Plant*....Jan. 1957 53
Shearer, J. L., and F. D. Ezekiel—*Pressure-Flow Characteristics of Pneumatic Valves*, ASME Annual Meeting....Dec. 1956 56
Sheppard, R., R. L. Jackson and S. B. Coulter—*Importance of Matching Steam Temperatures with Metal Temperatures During Starting of Large Steam Turbines*, ASME Annual Meeting....Jan. 1957 51
Sherbrooke, W. A., and H. Monroe, Jr.—*Air and Gas Duct System for the Gas-Turbine Vessel, "John Sergeant,"* ASME Annual Meeting....Dec. 1956 58
Silverberg, Michael—*Gas Coolant for Nuclear Reactors*, 1957 Nuclear Congress....Mar. 1957 61
Simpson, C. J. S., and J. W. Linnett—*Limits of Inflammability*, Sixth International Combustion Symposium....Oct. 1956 67
Singer, Joseph G., and Henry J. Blaskowski—*Gas Turbine Boiler Applications*....May 1957 38
Singer, Joseph M., J. Kenneth Richmond, E. B. Cook, James R. Oxendine, Joseph Grumer and David S. Burgess—*Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence*, Sixth International Combustion Symposium....Sept. 1956 77
Singer, Joseph M., and Guenther von Elbe—*Flame Propagation in Cylindrical Tubes Near the Quenching Limit*, Sixth International Combustion Symposium..Oct. 1956 62
Skog, L., Jr., and A. R. LeBailly—*Design and Characteristics of a Combined Gas and Steam Cycle of 40,000-Kw Capacity*, American Power Conf....Apr. 1957 44
Smith, J. O.—*Devising a Test for Plant Stack Stability*...Oct. 1956 57
Sobocinski, D. P., and R. L. Huntington—*Concurrent Flow of Air, Gas-Oil, and Water in a Horizontal Pipe*, ASME Annual Meeting....Jan. 1957 50
Spahr, J. C., C. B. Campbell and C. C. Franck, Sr.—*The Eddystone Superpressure Unit*, ASME Annual Meeting....Jan. 1957 46
Spalding, D. B.—*Ends and Means in Flame Theory*, Sixth International Combustion Symposium....Sept. 1956 75
Staebler, U. M.—*A General Survey of Reactor Economics*, Atomic Industrial Forum Conf....Nov. 1956 71
Stanley, R. J., H. J. Hupfer and A. H. Van Sickle—*In-Service Washing of Ljungstrom Air Preheaters on Pulverized-Coal-Fired Steam Generators*, ASME Annual Meeting....Jan. 1957 51
Stanojev, A. C.—*The Mechanical Features of the Shippingport Station*, Annual Water Conf....Nov. 1956 64
Starr, Dr. Chauncey—*Sodium-Graphite Reactor*, Atomic Industrial Forum Conf....Nov. 1956 69
Stevenson, C. E.—*The Fuel Cycle from the Standpoint of the Fuel Reprocessor*, 1957 Nuclear Congress....Mar. 1957 62
Straub, F. G.—*Comparison of the Reducing Power of Sodium Sulfite and Hydrazine in the Steam-Water Cycle of Steam Power Plants*....Jan. 1957 34
Styrikovich, M. A.—*Working Process of Super-High-Pressure Once-Through Boilers*....Sept. 1956 49

Page

Swett, Clyde C., Jr.—*Spark Ignition of Flowing Gases Using Long-Duration Discharges*, Sixth International Combustion Symposium ..... Oct. 1956 66
Townsend, S. C., W. E. Johnson and D. H. Fax—*The PAR Homogeneous Reactor Project*, ASME Annual Meeting ..... Dec. 1956 53
Travers, R. H.—*Automatic Economic Dispatching and Load Control—Ohio Edison System*, AIEE Winter General Meeting ..... Feb. 1957 64
Trilling, C. A.—*The Organic Moderated Reactor Experiment*, Atomic Industrial Forum Conf. ..... Nov. 1956 73
Tryoler, Jessee F.—*A Self-Calibrating High-Speed Photographic Pyrometer*, Sixth International Combustion Symposium ..... Oct. 1956 63
Tsivoglou, E. C., W. Marcus Ingram and E. C. Harward—*Stream Surveys for Radioactive Waste Control*, 1957 Nuclear Congress ..... Mar. 1957 64
Ulmer, Richard C.—*Water Treatment for Boilers—Natural Controlled Circulation, Once-Through* ..... Dec. 1956 61
Van Sickle, A. H., H. J. Hupfer and R. J. Stanley—*In-Service Washing of Ljungstrom Air Preheaters on Pulverized-Coal-Fired Steam Generators*, ASME Annual Meeting ..... Jan. 1957 51
Van Tiggelen, A., and J. Deckers—*Chain Branching and Flame Propagation*, Sixth International Combustion Symposium ..... Sept. 1956 76
Varon, B. E., and S. B. Applebaum—*An Application of Hot-Lime Zeolite to Moderate High-Pressure Boiler Operations*, American Power Conf. ..... Apr. 1957 47
von Elbe, Guenther, and Joseph M. Singer—*Flame Propagation in Cylindrical Tubes Near the Quenching Limit*, Sixth International Combustion Symposium ..... Oct. 1956 62
von Karman, Theodore—*The Present Status of the Theory of Laminar Flame Propagation*, Sixth International Combustion Symposium ..... Sept. 1956 75
Ward, F. R and G. R. Milne—*The Consolidated Edison Indian Point Nuclear Power Plant*, ASME Annual Meeting ..... Dec. 1956 53
Watson, W. R., and D. R. Anderson—*Soot Ignition Temperature Measurement* ..... Oct. 1956 43
Weaver, F. L., and M. A. Prohl—*High-Frequency Vibration of Steam-Turbine Buckets*, ASME Annual Meeting ..... Jan. 1957 50
Weinberg, F. J.—*Application of Optical Methods to Combustion Research*, Sixth International Combustion Symposium ..... Oct. 1956 64
Weisner, E. F., F. C. Gronemeyer, R. C. Gerber, H. M. Hagaman, H. B. Hols and H. A. Ross-Clunis—*Proposed 76,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska*, ASME Annual Meeting ..... Dec. 1956 53
Whipple, G. Hoyt—*Health Physics Instrumentation for a Power Reactor*, 1957 Nuclear Congress ..... Mar. 1957 64
Wilder, A. B., and A. F. Aebersold—*Yesterday, Today and Tomorrow—Pipeline Steels*, ASME Annual Meeting ..... Dec. 1956 55
Willa, J. L., and Technical Sub-Committee No. 2 of The Cooling Tower Institute—*Instrumenting a Field Study of Industrial Water-Cooling Tower Performance*, ASME Annual Meeting ..... Jan. 1957 60
Williams, G. C., H. C. Hottel and M. L. Baker—*Combustion Studies in a Stirred Reactor*, Sixth International Combustion Symposium ..... Sept. 1956 73
Wilson, C. D.—*Advances in the Field of Large Steam Turbines*, American Power Conf. ..... May 1957 60
Wilson, D. R.—*Advances in the Field of Large Steam Generators*, American Power Conf. ..... Apr. 1957 47
Wilson, W. B.—*Industrial Application for Combined Gas Turbine Steam Plants*, American Power Conf. ..... Apr. 1957 45
Wilson, W. B., M. M. Patterson and E. V. Pollard—*Economics of Higher Pressures and Temperatures for Steam Turbines in Industrial Plants*, American Power Conf. ..... May 1957 60
Wirth, Louis F., Jr.—*A Survey of Operating Hot-Lime-Zeolite Plants* ..... Apr. 1957 55
Wohlenberg, W. J.—*A Discussion of the Relations Existing Between Limiting Energy Release Rates and Blowout for Hydrocarbon Fuels*, Sixth International Combustion Symposium ..... Sept. 1956 73
Woodman, Walter C., Glenn A. Reed, and Robert J. Creagan—*The Yankee Atomic Electric Plant*, ASME Annual Meeting ..... Dec. 1956 51
Wolcott, J. R., V. A. Elliott, E. P. Peabody, G. M. Roy, W. L. Schans and G. Sege—*The Dresden Nuclear Station*, ASME Annual Meeting ..... Dec. 1956 51
Zumbrunnen, R. J., and S. B. Applebaum—*Selecting Water-Treating Processes for Medium-Pressure Boilers*, ASME Annual Meeting ..... Jan. 1957 48

CLASSIFIED

Boilers

Engineering the Eddystone Steam Generator for 5000 Psig, 1200 F Steam ..... Dec. 1956 43
Experimental Boiler Plant with Once-Through Boiler for Steam Conditions up to 4266 Psia, 1112 F. By K. A. Rakov, L. B. Krol, M. D. Panasenko and N. V. Bulgakova ..... Sept. 1956 42
Panel Construction Invades Medium Boiler Field. By F. S. Crofts ..... Jan. 1957 41
Working Process of Super-High-Pressure Once-Through Boilers. By M. A. Styrikovich ..... Sept. 1956 49

Coal and Ash Handling Systems

Case History of Automatic Ash and Dust Handling Progress, A. By B. C. Berry ..... June 1957 45

Compressors

Equivalent Performance Parameters for Turboblowers, Compressors, *ASME Annual Meeting*. By H. Davis Dec. 1956 58

Condensers

Aluminum Condenser Tubes, A Report on a Plant Installation, *American Power Conf.* By W. A. Pollock. May 1957 59

Controls

Dynamics of Pressure and Combustion Control in Steam Generators. By Dr. P. Profos ..... Mar. 1957 34

Cooling Towers

Cooling Towers for Steam-Electric Stations—Selection and Performance Experiences, *ASME Annual Meeting*. By M. W. Larinoff ..... Jan. 1957 60
Instrumenting a Field Study of Industrial Water-Cooling Tower Performance, *ASME Annual Meeting*. By J. L. Willa and Technical Sub-Committee No. 2 of The Cooling Tower Institute ..... Jan. 1957 60

Corrosion

Investigation into the Air-Heater Corrosion of Oil-Fired Boilers, An. By B. Lees ..... July 1956 38

Design

Advances in the Field of Large Steam Generators, *American Power Conf.* By D. R. Wilson ..... Apr. 1957 47
Design and Characteristics of a Combined Gas and Steam Cycle of 40,000-Kw Capacity, *American Power Conf.* By A. R. LeBailly and L. Skog, Jr. ..... Apr. 1957 44
Economics of Medium-Sized Supercharged Power Plants, *American Power Conf.* By E. L. Daman and E. L. Richardson ..... Apr. 1957 46
Engineering the Eddystone Plant for 5000 Psig, 1200 F Steam, *ASME Annual Meeting*. By J. H. Harlow ..... Jan. 1957 46
Engineering the Eddystone Steam Generator for 5000 Psig, 1200 F. By E. M. Powell ..... Dec. 1956 43
Liquid Metal in a Double-Reheat, Fuel-Fired Steam Plant. By E. W. Burstadt, D. E. Hart, L. J. Marshall and H. R. Shannon ..... Jan. 1957 53
New Way to Simplify the Steam Power Plant, A. By H. A. Kuljian and W. J. Fadden, Jr. ..... July 1956 51
Outdoor Versus Indoor Steam-Electric Stations in the Houston Area. By L. K. Del'Homme ..... Sept. 1956 55

Dust Collectors

Dust Collectors for Central Station Steam Power Plants. By M. J. Archbold ..... Aug. 1956 34

Fuels

Competition, Substitution and Demand Among Fuels, *ASME Annual Meeting*. By Paul W. McGann ..... Dec. 1956 57
Development of an Explosive Gas-Air Mixture Detector, *Sixth International Combustion Symposium*. By Harold M. Brewster ..... Oct. 1956 65
Evaluating Coal by Utilization Cost, *ASME Annual Meeting*. By W. H. Attwill, C. D. Day, Jr. and A. J. Johnson ..... Dec. 1956 57
Fly Ash Refiring. By Wallace W. Maull and Earl C. McMahon ..... Nov. 1956 40
Limits of Inflammability, *Sixth International Combustion Symposium*. By J. W. Linnett, C. J. S. Simpson Oct. 1956 67
Spark Ignition of Flowing Gases Using Long-Duration Discharges, *Sixth International Combustion Symposium*. By Clyde C. Swett, Jr. ..... Oct. 1956 66

Gas Turbines

Air and Gas Duct System for the Gas-Turbine Vessel, John Sergeant, *ASME Annual Meeting*. By W. A. Sherbrooke and H. Monroe, Jr. ..... Dec. 1956 58
Coal-Fired Gas Turbine, *BCR Techno-Sales Conf.* By P. R. Broadley and W. M. Meyer ..... May 1957 65
Gas Turbine Boiler Applications. By Henry J. Blaskowski and Joseph G. Singer ..... May 1957 38
Industrial Application for Combined Gas Turbine Steam Plants, *American Power Conf.* By W. B. Wilson ..... Apr. 1957 45
New Gas Turbine for Industrial Applications, A. ..... Aug. 1956 44
Potential for the Coal-Burning Gas Turbine, *BCR Techno-Sales Conf.* By John W. Igoe ..... May 1957 65
Pressure Drop and Air Flow Distribution in Gas-Turbine Combustors, *ASME Annual Meeting*. By J. S. Grobman and R. T. Dittrich ..... Dec. 1956 58

Heat Transfer

Bubble Contact Heaters for Power Plants. By George P. Kotelewskij ..... Sept. 1956 65

Page

New Way to Simplify the Steam Power Plant, A. By H. A. Kuljian and W. J. Fadden, Jr. ..... July 1956 51

Industrial Power

Industrial Power Plant Developments. By E. R. Lee, Jr. and E. F. Boobyer ..... Mar. 1957 45

Installations

Avon Plant, The Cleveland Electric Illuminating Co. Avon No. 8—A Supercritical Pressure Plant. By C. A. Dauber ..... Aug. 1956 47
Eddystone Station, Philadelphia Electric Co. Eddystone Supercritical Heat Cycle Incorporates Stack Gas Heat. By Samuel M. Arnow ..... Apr. 1957 34
Eddystone Station, Philadelphia Electric Co. Engineering the Eddystone Steam Generator for 5000 Psig, 1200 F. By E. M. Powell ..... Dec. 1956 43
Kaiser Aluminum & Chemical Corp. Industrial Power Plant Developments. By E. R. Lee, Jr. and E. F. Boobyer ..... Mar. 1957 45

Instruments

Health Physics Instrumentation for a Power Reactor, 1957 Nuclear Congress. By G. Hoyt Whipple ..... Mar. 1957 64
Measurement of Gas Temperatures with Thermocouples. By R. C. Corey ..... Oct. 1956 47
Precision Valve Point Loading of Turbines Using a Digital Computer Saves Dollars, *American Power Conf.* By Aaron D. Brooks ..... May 1957 62
Quality Measurements by Flame Photometer. By J. K. Rice ..... Nov. 1956 57

Materials

Aluminum Condenser Tubes, A Report on a Plant Installation, *American Power Conf.* By W. A. Pollock ..... May 1957 59
Austenitic Steels in High-Temperature Steam Piping, *ASME Annual Meeting.* By R. M. Curran and A. W. Rankin ..... Jan. 1957 49
Metallurgical Considerations of Main Steam Piping for High-Temperature, High-Pressure Service, *ASME Annual Meeting.* By H. S. Blumberg ..... Jan. 1957 49
Properties of Cast Iron at Elevated Temperatures—A Progress Report. By J. R. Kattus ..... June 1957 49

Nuclear Energy

Army Package Power Reactor, The ..... May 1957 46
Atomic Industrial Forum Conference of 1956 ..... Nov. 1956 69
Consolidated Edison Indian Point Nuclear Power Plant, *ASME Annual Meeting.* By G. R. Milne, and F. R. Ward ..... Dec. 1956 53
Development of Safety Standards for Nuclear Propulsion of Merchant Ships, *1957 Nuclear Congress.* By Capt. Charles P. Murphy and Arthur R. Gatewood ..... Mar. 1957 63
Dresden Nuclear Station, The, *ASME Annual Meeting.* By J. R. Wolcott, V. A. Elliott, E. P. Peabody, G. M. Roy, J. L. Schanz and G. Sege ..... Dec. 1956 51
EBWR Goes on the Line ..... Mar. 1957 53
Economic Background for the Competitive Development of Nuclear Power, *1957 Nuclear Congress.* By Harlan W. Nelson and W. R. Keagy, Jr. ..... Mar. 1957 59
Economics of Pressurized Water Reactors Fueled with Uranium-235 and Thorium, *Atomic Industrial Forum Conf.* By W. T. Moore ..... Nov. 1956 70
Enrico Fermi Atomic Power Plant, *ASME Annual Meeting.* By John F. Anderson, Weymouth N. McDaniel and Charles M. Heidel ..... Dec. 1956 5
Fifth Annual Conference on Atomic Energy ..... Apr. 1957 59
Fuel Cycle from the Standpoint of the Fuel Reprocessor, *1957 Nuclear Congress.* By C. E. Stevenson ..... Mar. 1957 62
Fuel Cycles in Single-Region Thermal Reactors, *1957 Nuclear Congress.* By Manson Benedict and Thomas H. Pigford ..... Mar. 1957 62
Gas Coolant for Nuclear Reactors, *1957 Nuclear Congress.* By Michael Silverberg ..... Mar. 1957 61
Gas Turbine Reactor, The, *Atomic Industrial Forum Conf.* By Theodore Jarvis ..... Nov. 1956 73
General Survey of Reactor Economics, A, *Atomic Industrial Forum Conf.* By U. M. Staebler ..... Nov. 1956 71
Health Physics Instrumentation for a Power Reactor, *1957 Nuclear Congress.* By G. Hoyt Whipple ..... Mar. 1957 64
Influence of the National Academy of Science's Report on the Nuclear Power Industry, *Atomic Industrial Forum Conf.* By J. W. Healy ..... Nov. 1956 75
Liquid Metal Fueled Reactor, *Atomic Industrial Forum Conf.* By Milton C. Edlund ..... Nov. 1956 71
Organic Moderated Reactor Experiment, The, *Atomic Industrial Forum Conf.* By C. A. Trilling ..... Nov. 1956 73
PAR Homogeneous Reactor Project, The *ASME Annual Meeting.* By W. E. Johnson, D. H. Fax and S. C. Townsend ..... Dec. 1956 53
Proposed 75,000-Kw Sodium Graphite Reactor for the Consumers Public Power District of Nebraska, *ASME Annual Meeting.* By F. C. Gronemeyer, R. C. Gerber, H. M. Hagaman, H. B. Holz, H. A. Ross-Clunis and E. F. Weisner ..... Dec. 1956 53

Page

Reactor Safety: Round Table Sponsored by Nuclear Energy Writers Assoc., *Atomic Industrial Forum Conf.* ..... Nov. 1956 75
Sodium Deuterium Reactor, The, *Atomic Industrial Forum Conf.* By Willard S. Mott ..... Nov. 1956 74
Sodium-Graphite Reactor *Atomic Industrial Forum Conf.* By Dr. Chauncey Starr ..... Nov. 1956 67
Stream Surveys for Radioactive Waste Control, *1957 Nuclear Congress.* By E. C. Tsivoglou, W. Marcus Ingram and E. D. Harward ..... Mar. 1957 64
Thermal Problems of Atomic Power Stations. By C. E. Lundgren and C. Seippel—I ..... Feb. 1957 51
—II ..... June 1957 51
Yankee Atomic Electric Plant, the, *ASME Annual Meeting.* By Glenn A. Reed, Robert J. Creagan and Walter C. Woodman ..... Dec. 1956 51

Operating Experience

Allocating Heat Energy in an Industrial Plant. By Ronald J. Martin ..... Apr. 1957 49
Distribution of Steam and Electric Power Costs in an Industrial Plant, *American Power Conf.* By Howard P. Kallen ..... May 1957 62
Importance of Matching Steam Temperatures with Metal Temperatures During Starting of Large Steam Turbines, *ASME Annual Meeting.* By R. L. Jackson, S. B. Coulter and R. Sheppard ..... Jan. 1957 51
Incremental Efficiency Testing of Industrial Turbine Generators to Determine Valve Points, Saves Kilowatts, *American Power Conf.* By Gerald L. Decker ..... May 1957 62
In-Service Washing of Ljungstrom Air Preheaters on Pulverized-Coal-Fired Steam Generators, *ASME Annual Meeting.* By H. J. Hupfer, R. J. Stanley and A. H. Van Sickle ..... Jan. 1957 51
Integrating Steam and Hydro Power in Northern and Central California, *American Power Conf.* By Walter Dreyer ..... May 1957 63
Investigation into the Air-Heater Corrosion of Oil-Fired Boilers. By B. Lees ..... July 1956 38
Operating Experiences with Twin Furnace Boilers, *American Power Conf.* By E. M. Powell ..... Apr. 1957 46
Oxygen Monitor in Flue Gases Aids Combustion Efficiency ..... Jan. 1957 61
Precision Valve Point Loading of Turbines Using a Digital Computer Saves Dollars, *American Power Conf.* By Aaron D. Brooks ..... May 1957 62
Steam Power Plant Maintenance Costs. By H. E. Roberts ..... Dec. 1956 38

Piping

Austenitic Steels in High-Temperature Steam Piping, *ASME Annual Meeting.* By R. M. Curran and A. W. Rankin ..... Jan. 1957 49
Concurrent Flow of Air, Gas-Oil, and Water in a Horizontal Pipe, *ASME Annual Meeting.* By D. P. Sobocinski and R. L. Huntington ..... Jan. 1957 50
Creep Characteristics of Type 347 Stainless Steel at 1050 and 1100 F in Tension and Compression, *ASME Annual Meeting.* By M. J. Manjoine ..... Dec. 1956 56
Eight Years of Experience with Austenitic-Steel Piping Materials at Elevated Steam Conditions, *ASME Annual Meeting.* By E. P. Fairchild ..... Dec. 1956 54
Investigation of Thermal Stress Fatigue as Related to High-Temperature Piping Flexibility, *ASME Annual Meeting.* By L. F. Coffin, Jr. ..... Dec. 1956 56
Losses in Pipe and Fittings, *ASME Annual Meeting.* By R. J. S. Pigott ..... Jan. 1957 50
Metallurgical Considerations of Main Steam Piping for High-Temperature, High-Pressure Service, *ASME Annual Meeting.* By H. S. Blumberg ..... Jan. 1957 49
NEMA Approves Piping Standards for Industrial-Service Turbines ..... June 1957 35
On the Quality Requirements for Steam Valves for Nuclear Power Plants, *1957 Nuclear Congress.* By J. J. Kanter ..... Mar. 1957 60
Pressure-Flow Characteristics of Pneumatic Valves, *ASME Annual Meeting.* By F. D. Ezekiel and J. L. Shearer ..... Dec. 1956 56
Resistance Coefficients for Laminar and Turbulent Flow Through One-Half Inch Valves and Fittings, *ASME Annual Meeting.* By C. P. Kittridge and D. S. Rowley ..... Dec. 1956 55
Yesterday, Today and Tomorrow—Pipeline Steels, *ASME Annual Meeting.* By A. B. Wilder and A. F. Aebersold ..... Dec. 1956 55

Power Statistics

Some Factors in the Economic Generation of Power by TVA System, *American Power Conf.* By Robert A. Monroe ..... May 1957 63

Pumps

Boiler Feed Pumps for 6500-Psi Discharge Pressure, *American Power Conf.* By H. Hornschuch ..... May 1957 61
Progress Report on High-Speed Boiler Feed Pumps, *American Power Conf.* By Igor J. Karassik and T. W. Edwards ..... May 1957 61

Page

Steam Power Plant Trends and Their Effect on the Boiler Feed Pump. By I. J. Karassik. Part I.....Oct. 1956 36
Part II....Nov. 1958 51

Research

Application of Optical Methods to Combustion Research, *Sixth International Combustion Symposium.* By F. J. Weinberg.....Oct. 1956 64
Chain Branching and Flame Propagation, *Sixth International Combustion Symposium.* By A. Van Tiggelen and J. Deckers.....Sept. 1956 76
Combustion Studies in a Stirred Reactor, *Sixth International Combustion Symposium.* By H. C. Hottel, G. C. Williams and M. L. Baker.....Sept. 1956 73
Current BCR Program, The, *BCR Techno-Sales Conf.* By James R. Garvey.....May 1957 66
Discussion of the Relations Existing Between Limiting Energy Release Rates and Blowout for Hydrocarbon Fuels, A, *Sixth International Combustion Symposium.* By W. J. Wohlenberg.....Sept. 1956 74
Effect of Pressure on Flame Propagation, *Sixth International Combustion Symposium.* Panel Discussion: R. S. Brokaw, Melvin Gerstein, Mitchell Gilbert, Donald Smith, John T. Agnew, E. S. Gilvina and G. G. Fyodorov.....Oct. 1956 61
Ends and Means in Flame Theory, *Sixth International Combustion Symposium.* By D. B. Spalding.....Sept. 1956 75
Flame Propagation in Cylindrical Tubes Near the Quenching Limit, *Sixth International Combustion Symposium.* By Joseph M. Singer and Guenther von Elbe.....Oct. 1956 62
Method of Measuring the Temperature of Burning Fuel Particles in Motion, *Sixth International Combustion Symposium.* By V. A. Popov.....Oct. 1956 62
Power Engineer Looks Ahead Ten Years, A. By Theodore Baumeister.....May 1957 53
Present Status of the Theory of Laminar Flame Propagation, The, *Sixth International Combustion Symposium.* By Theodore von Karman.....Sept. 1956 75
Research—The Window of Tomorrow, *BCR Techno-Sales Conf.* By Joseph W. Barker.....May 1957 65
Self-Calibrating High-Speed Photographic Pyrometer, *Sixth International Combustion Symposium.* By Jessee F. Tryoler.....Oct. 1956 63
Soot Ignition Temperature Measurement. By D. R. Anderson and W. R. Watson.....Oct. 1956 43
Structure of Laminar Flame Fronts, The, *Sixth International Combustion Symposium.* By R. M. Friston..Oct. 1956 61
Thermoelectric Probes for Measuring High Temperatures in Gas Streams: Their Application to the Study of Flames Stabilized by Obstacles, *Sixth International Combustion Symposium.* By G. Matton and C. Foure.....Oct. 1956 62
Turbulent Burning Velocities of Natural Gas-Air Flames with Pipe-Flow Turbulence, *Sixth International Combustion Symposium*.....Sept. 1956 77

Stacks

Devising a Test for Plant Stack Stability. By Jack Smith.....Oct. 1956 57

Steam

Projecting Steam Costs to 1980. By James H. Harlow June 1957 41

Steam Pressures, Temperatures and Cycles

Economics of Higher Pressures and Temperatures for Steam Turbines in Industrial Plants, *American Power Conf.* By M. M. Patterson, E. V. Pollard and W. B. Wilson.....May 1957 60
Eddystone Supercritical Heat Cycle Incorporates Stack Gas Heat. By Samuel M. Arnow.....Apr. 1957 34
Future of the Steam Turbine Cycle, *American Power Conf.* By C. W. Elston, and J. E. Downs.....May 1957 59
Projecting Steam Costs to 1980. By James H. Harlow June 1957 41

Steam Turbine-Generators

Advances in the Field of Large Steam Turbines, *American Power Conf.* By C. D. Wilson.....May 1957 60
Economics of Higher Pressures and Temperatures for Steam Turbines in Industrial Plants, *American Power Conf.* By M. M. Patterson, E. V. Pollard and W. B. Wilson.....May 1957 60
Eddystone Superpressure Unit, The, *ASME Annual Meeting.* By C. B. Campbell, C. C. Franck, Sr. and J. C. Spahr.....Jan. 1957 46
Future of the Steam Turbine Cycle, *American Power Conf.* By C. W. Elston and J. E. Downs.....May 1957 59
High-Frequency Vibration of Steam-Turbine Buckets, *ASME Annual Meeting.* By F. L. Weaver and M. A. Prohl.....Jan. 1957 50
Incremental Efficiency Testing of Industrial Turbine-Generators to Determine Valve Points, Saves Kilowatts, *American Power Conf.* By Gerald L. Decker..May 1957 62
Method for Calculating Vibration Frequency and Stress of a Banded Group of Turbine Buckets, *ASME Annual Meeting.* By M. A. Prohl.....Jan. 1957 50

Page

NEMA Approves Piping Standards for Industrial-Service Turbines.....June 1957 35
Precision Valve Point Loading of Turbines Using a Digital Computer Saves Dollars, *American Power Conf.* By Aaron D. Brooks.....May 1957 62

Television

Special Television Camera Features at German Industry Fair.....Aug. 1956 57

Valves

On the Quality Requirements for Steam Valves for Nuclear Power Plants, *1957 Nuclear Congress.* By J. J. Kanter.....Mar. 1957 60

Water Conditioning

Anion Exchange Subfill as a Factor in Demineralizer Rinse Requirements, *American Power Conf.* By J. H. Duff and Robert Dvorin.....Apr. 1957 48
Application of Hot-Lime Zeolite to Moderate High-Pressure Boiler Operations, An, *American Power Conf.* By B. E. Varon and S. B. Applebaum.....Apr. 1957 47
Automation of Water Treating Equipment, *Annual Water Conf.* By Paul H. Coleman.....Nov. 1956 63
Comparison of the Reducing Power of Sodium Sulfite and Hydrazine in the Steam-Water Cycle of Steam Power Plants. By Frederick G. Straub.....Jan. 1957 34
Conductivity Versus Sodium by Flame Spectrophotometer in Steam-Purity Studies, *ASME Annual Meeting.* By C. A. Bishof, J. K. Brown and H. L. Kahler Jan. 1957 48
Costs of Cation Exchange Equipment. By R. F. Peak and M. M. David.....May 1957 48
Evaporated Make-Up Water for a Monotube Boiler, *ASME Annual Meeting.* By R. F. Andres.....Jan. 1957 48
Experiences With the Turner Scale Thickness Indicator, *Annual Water Conf.* By L. B. Losee.....Nov. 1956 67
History of Ion Exchange and Some Interesting Recent Development, The. By O. M. Elliott.....July 1956 57
Inspection of Non-Magnetic Tubing in Corrosive Service by the Probolog Method, *Annual Water Conf.* By Frank U. Neat.....Nov. 1956 66
Instrumentation for the Determination of Steam Purity, *Annual Water Conf.* By E. A. Pirsh and F. G. Raynor.....Nov. 1956 65
Mechanical Features of the Shippingport Station, The, *Annual Water Conf.* By A. C. Stanojev.....Nov. 1956 64
Mixed-Bed Demineralizer Operations at AEC Facilities, Oak Ridge, Tenn., *Annual Water Conf.* By Gordon W. Brush, S. B. Applebaum and Gustave J. Angele...Nov. 1956 65
Non-Destructive Thickness Measurements of Boiler Deposits, *Annual Water Conf.* By F. N. Alquist and A. M. Guy.....Nov. 1956 67
Nuclear Water Technology, *Annual Water Conf.* By Paul Cohen.....Nov. 1956 64
Operating Experiences with a Large Hot-Lime Zeolite System for 1500-Psi Boilers, *American Power Conf.* By J. E. Harden and Glenn R. Hull.....Apr. 1957 47
Performance of the Demineralizer in the Preparation of High Quality Water, *ASME Annual Meeting.* By I. B. Dick.....Jan. 1957 47
Polymeric Coagulants for Clarification of Turbid Waters, *Annual Water Conf.* By R. Kirkconnell....Nov. 1956 63
Present Status of Electric Membrane Demineralization, The, *Annual Water Conf.* By William Katz.....Nov. 1956 67
Quality Measurements by Flame Photometer. By J. K. Rice.....Nov. 1956 57
Recent Application Results of the Hydrazine-Sodium Sulfite Combination, *American Power Conf.* By Robert T. Hess and Warren A. Greten.....Apr. 1957 48
Selecting Water-Treating Processes for Medium-Pressure Boilers, *ASME Annual Meeting.* By S. B. Applebaum and R. J. Zumbrunnen.....Jan. 1957 48
Seventeenth Annual Water Conference.....Nov. 1956 63
Survey of Operating Hot-Lime Zeolite Plants. By L. F. Wirth, Jr.....Apr. 1957 55
Three Years Experience with Hydrazine, *American Power Conf.* By M. D. Baker.....Apr. 1957 48
Use of the Bureau of Mines Condensate-Corrosion Tester for the Survey of Return-Line Deterioration, *ASME Annual Meeting.* By A. A. Berk.....Jan. 1957 49
Water Treatment for Boilers—Natural Controlled Circulation, Once-Through. By R. C. Ulmer.....Dec. 1956 61
What Do Modern High-Pressure Boilers Demand of Feedwater?, *ASME Annual Meeting.* By P. F. Baggish.....Jan. 1957 47

Miscellaneous

American Power Conference in Review—I.....Apr. 1957 44
—II.....May 1957 59
American Power Conference Program.....Mar. 1957 65
ASME Annual Meeting in Review—I.....Dec. 1956 51
—II.....Jan. 1957 46
BCR's Techno-Sales Conference.....May 1957 65
Cleveland Host to ASME Semi-Annual Meeting.....July 1956 65
Cri de Coeur or the Problems of a Soviet Chief Designer .July 1956 62
Design and Development of a Two-Cycle Turbocharged Diesel Engine, *ASME Annual Meeting.* By P. J. Louseeky.....Dec. 1956 57

	Page
Development of Supercharged Medium-Speed Two-Cycle Opposed Piston Engine, *ASME Annual Meeting*. By A. K. Antonsen.....Dec. 1956	56
Engineering Educators Meet at Iowa State College.....Aug. 1956	59
Founder Societies Vote to Keep Headquarters in N.Y.C. Dec. 1956	67
New Type Automatic Dispatching System at Kansas City, A, *ASME Annual Meeting*. By D. H. Cameron and E. L. Mueller.....Dec. 1956	59
Power Practices in 1956.....Jan. 1957	44
Problems Related to the Location of Generating Plants, Transmission Facilities and Substations. By L. W. Cadwallader.....July 1956	45
PWR Vessel En Route from Chattanooga to Shipping-port.....Nov. 1956	47
Sixth International Combustion Symposium Convenes at Yale University.....Sept. 1956	73
Special Television Camera Features at German Industry Fair.....Aug. 1956	57

BOOK REVIEWS

	Page
ASTM Standards on Copper and Copper Alloys. ASTM Publication.....May 1957	68
ASTM Standards on Light Metals and Alloys, Cast and Wrought. ASTM Publication.....July 1956	71
America's Resources of Specialized Talent. By Dael Wolfle.....July 1956	72
Bibliography and Index on Dynamic Pressure Measurement. By W. G. Brombacher and T. W. Lashof.....July 1956	71
Commercial and International Developments in Atomic Energy. Atomic Industrial Forum.....Aug. 1956	63
Compilation of Chemical Compositions and Rupture Strengths of Super-Strength Alloys. ASTM Publication.....July 1956	70
Design of Piping Systems. Prepared by the Engineering Dept. of The M. W. Kellogg Co.....May 1957	66
Elevated Temperature Properties of Carbon Steels. ASTM Publication.....Dec. 1956	70
Fifth Symposium (International) on Combustion. Edited by the Standing Committee on Combustion Symposia of the Combustion Institute.....July 1956	70
Guide to Instrumentation Literature. By W. G. Brombacher, Julian F. Smith and Lyman M. Van der Pyl.....Dec. 1956	70
Industrial Purchasing. By J. H. Westing and I. V. Fine.....Aug. 1956	62
Mechanical Properties of Wrought Phosphor Bronze Alloys, The. ASTM Publication.....Dec. 1956	70
Panel Discussion on Pyrometric Practices. ASTM Publication.....Dec. 1956	70
Plant Operators' Manual. By Stephen Elonka.....Dec. 1956	70
Problems and Control of Air Pollution. Edited by F. S. Mallette.....July 1956	70
Reactions of Carbon with Carbon Dioxide and with Steam. By C. G. von Federsdorff.....May 1957	67
Specifications and Tests for Electrodeposited Metallic Coatings. ASTM Publication.....Dec. 1956	69
Symposium on Atmospheric Corrosion of Non-Ferrous Metals. ASTM Publication.....May 1957	68
Symposium on Basic Effects of Environment on the Strength, Scaling and Embrittlement of Metals at High Temperatures. ASTM Publication.....Dec. 1956	69
Symposium on Impact Testing. ASTM Publication.....May 1957	68
Symposium on Metallic Materials for Service at Temperatures Above 1600 F. ASTM Publication.....Dec. 1956	69

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Reactions of Carbon with Carbon Dioxide and with Steam

By C. G. von Federsdorff

Institute of Gas Technology Research Bulletin No. 19, 76 pages, $7.50

This bulletin contains the results of ten years of study of two of the fundamental reactions in the production of manufactured gas. Studies of reactions in the temperature range of 1700 to 2500 F between a solid fuel and oxidizing gases are presented as (*a*) the development of mathematical procedures which may have general use in estimating physical and chemical factors associated with carbon gasification, and (*b*) application of these procedures to the interpretation of steam and carbon dioxide decomposition rates and gas analyses.

Most of the experimental data were obtained with continuous-flow fixed-bed reactors operating at atmospheric and superatmospheric pressures in the Institute's laboratories in Chicago. Results reported by others are analyzed in a literature study and addendum.

Design of Piping Systems

John Wiley & Sons, 365 pages, $15

A second edition of this authoritative book has been prepared by members of the engineering departments of The M. W. Kellogg Company. A complete investigation of structural design is included with emphasis on the flexibility analysis of critical systems.

In chapters I and II, Strength and Failure of Materials and Design Assumptions, Stress Evaluation; and Design Limits, and again in the third chapter on Local Components, which treats the effect of piping reactions on local and terminal components of a piping system, there is much material to aid the designer to understand the significance of stresses in piping performance. Chapter 4, Simplified Method for Flexibility Analysis, contains several newly developed approaches that facilitate the general assessment of average piping or are helpful in the planning stage of critical piping design.

Offering an unusually complete treatment of the thermal expansion problem, the new edition also gives a method for calculating the effects of uniform loading, such as that due to weight or wind. A chapter entitled Supporting, Restraining, and Bracing the Piping System covers the various problems of supporting critical piping systems, while a chapter on Vibration: Prevention and Control approaches the subject from the standpoint of the piping designer, with the objective of achieving vibration free piping in the design phase of a subject.

Other chapters deal with flexibility analysis by the general analytical methods and by model test, and approaches for reducing expansion effects. An extensive appendix includes the history and derivation of piping flexibility analysis, derivation of acoustic vibration formulas, and various charts and tables.

The engineering profession has received many benefits from the willingness of companies to share technical information, much of which was originally developed at great expense to individual organizations. This book is an outstanding example of such enlightened sharing to the benefit of all.

COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Avenue, New York 16, N. Y.

Enclosed find check for $..... for which send me books listed by the number.

NAME_____ **Book Nos.** _____

ADDRESS_____

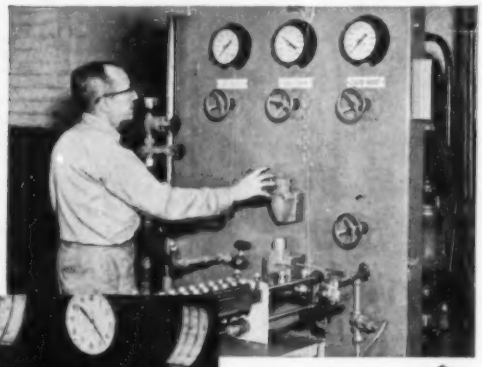
Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.

Sharp visibility for *all* your liquid levels with EYE-HYE® Remote Reading Gage

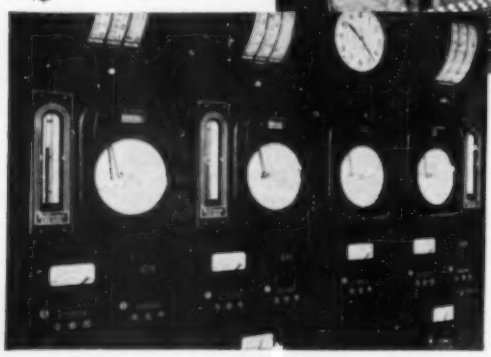
Most important for quick-reading mistake-proof gage equipment are your main boilers — naturally! But other liquid levels need watching — some that can't have "main floor" prominence or convenience.

EYE-HYE brings *all* gage reading out front, to a central point or to locations frequently passed by operators. (See list below.)

Simple, fool-proof, easy to read (illuminated green liquid represents water level), EYE-HYE is made for pressures up to 2500 psi — water level variation to 12 feet. New wide vision face plate makes reading visible from wide area. Write for specific recommendations to bring your gage facilities up to date.



Close-up of panel board section at an important research center where 3 EYE-HYEs serve the main boilers.



How EYE-HYE assemblies get hydraulic test at nearly twice their cataloged pressure rating.

Main boilers **Flash tanks**
Feed Water Heaters
Water treatment systems
Waste heat boilers
Storage tanks

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio

Advertisers' Index

Aerotec Corporation, The..... 79
Air Preheater Corporation, The 23
Allis-Chalmers Mfg. Company, Construction Machinery Div. *
Allis-Chalmers Mfg. Company, General Machinery Div..... *
American Blower Corporation. .....8 and 9

Bailey Meter Company..... 10
Baltimore & Ohio Railroad.... 11
Bayer Company, The..... 68
Bituminous Coal Institute.... 67
Blaw-Knox Company, Blaw-Knox Equipment Div..... *
Blonder-Tongue Laboratories, Inc..... *
Buell Engineering Company, Inc..... 32

Cambridge Instrument Company..... *
Carborundum Company, The. *
Chesapeake & Ohio Railway... *
Clarage Fan Company..... *
Combustion Engineering, Inc.. .....Second Cover, 12 and 13
Combustion Publishing Company, Inc..... 77
Copes-Vulcan Div., Blaw-Knox Company.....6 and 7
Crane Company..... 69
Curtiss-Wright Corp..... *

Dampney Company, The..... 24
Dearborn Chemical Company. *
De Laval Steam Turbine Company..... 65
Diamond Power Specialty Corporation.....5, Third Cover
Dowell Inc.....Fourth Cover

Eastern Gas & Fuel Associates. 19
Economy Pumps, Inc..... *
Edward Valves, Inc.....20 and 21
Euclid Division, General Motors Corporation..... *

Fairmount Chemical Co., Inc. 61
Flexitallic Gasket Company... *
Fly Ash Arrestor Corporation, The..... 30

General Electric Company.... *
General Refractories Company 63
Gifford-Wood Co..... *
Graver Water Conditioning Company..... 31

Hagan Chemicals & Controls, Inc..... *
Hall Laboratories, Div. of Hagan Chemicals & Controls, Inc..... 15
Haskins-Turner Company..... *

(*Continued on page 79*)

Ingersoll-Rand Company..... *

Johns-Manville..... *

M. W. Kellogg Company, The.. *
Koppers Company, The..... *

L. A. Water Softener Company. *
Leeds & Northrup Company... 66
Lukens Steel Company..... 18
Lummus Company, The..... *

W. K. Mitchell & Company... 70

National Aluminate Corporation..... *
Norfolk and Western Railway.. 4

Pacific Pumps, Inc..... *
Peabody Engineering Corporation..... *
Pennsylvania Crusher Div., Bath Iron Works Corp..... *
Pittsburgh Piping & Equipment Company..... 22
Powell Valves..... *
Prat-Daniel Corporation..... *
Henry Pratt Company..... *

Refractory & Insulation Corporation..... 64
Reliance Gauge Column Company, The..... 78
Republic Flow Meters Company..... *
Republic Steel Corporation.... *
Research-Cottrell, Inc..... 17
Richardson Scale Company... 50

Standard Tube Company, The. 26
Stock Equipment Company... 80
Sy-Co Corporation..... *

W. A. Taylor and Co..... 60
Todd Shipyards Corp., Products Div..... 61

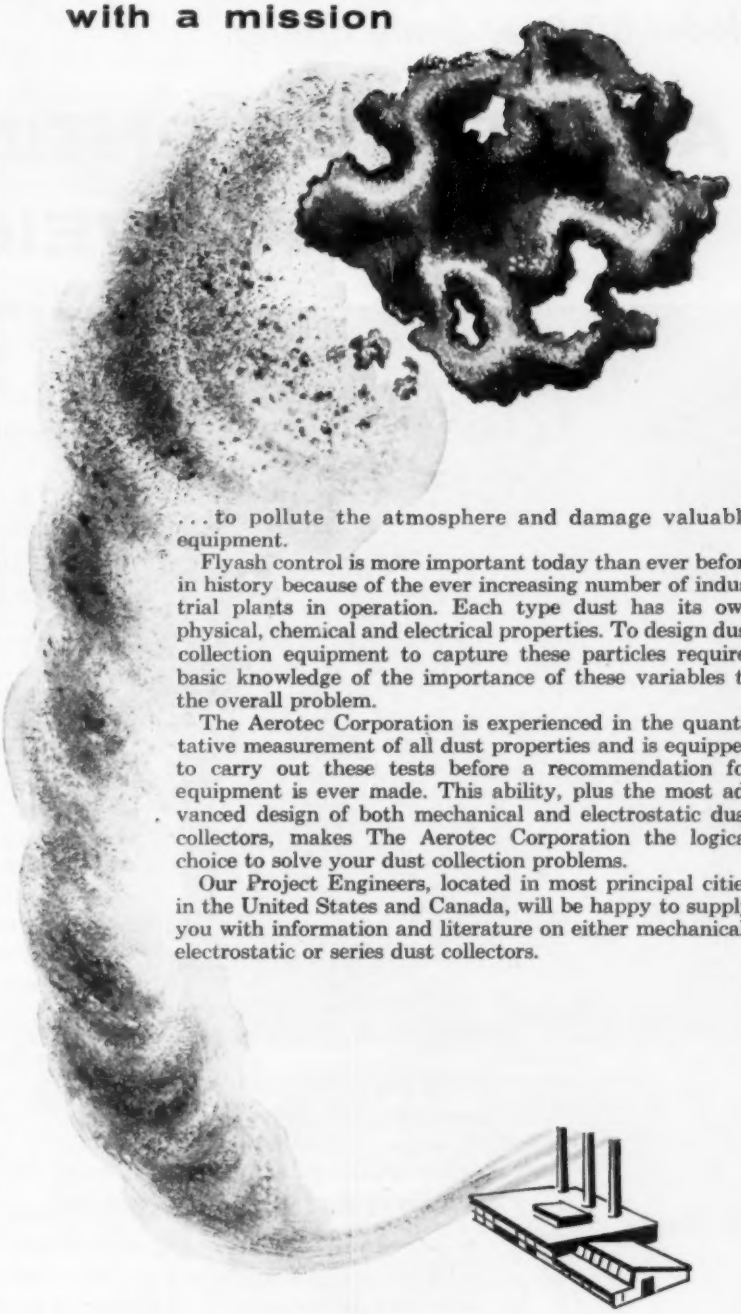
Unafrax Construction Company..... 60

Walworth Company..... 25
Western Precipitation Corporation..... 14
Westinghouse Electric Corp... 16
Westinghouse Electric Corporation, Sturtevant Div..... *
C. H. Wheeler Manufacturing Company..... *
L. J. Wing Mfg. Co..... 62
Worthington Corp.....28 and 29

Yarnall-Waring Company.....
.....2, 3 and 27

Dust Particle

with a mission



...to pollute the atmosphere and damage valuable equipment.

Flyash control is more important today than ever before in history because of the ever increasing number of industrial plants in operation. Each type dust has its own physical, chemical and electrical properties. To design dust collection equipment to capture these particles requires basic knowledge of the importance of these variables to the overall problem.

The Aerotec Corporation is experienced in the quantitative measurement of all dust properties and is equipped to carry out these tests before a recommendation for equipment is ever made. This ability, plus the most advanced design of both mechanical and electrostatic dust collectors, makes The Aerotec Corporation the logical choice to solve your dust collection problems.

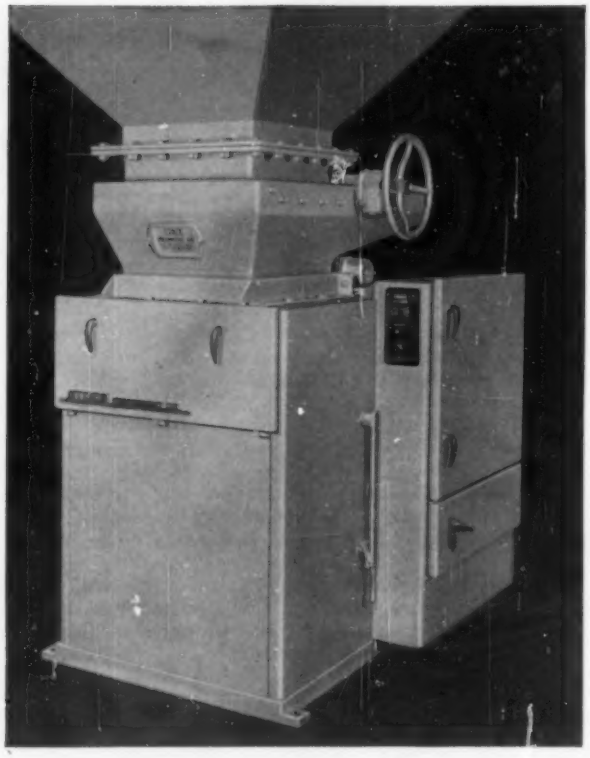
Our Project Engineers, located in most principal cities in the United States and Canada, will be happy to supply you with information and literature on either mechanical, electrostatic or series dust collectors.

Project Engineers **THE THERMIX CORPORATION** Greenwich, Conn.
(Offices in 38 principal cities)
Canadian Affiliates: T. C. CHOWN, LTD., 164 Metcalfe Ave., Westmount, Montreal 6, Que.

Manufacturers
THE AEROTEC CORPORATION
Greenwich, Conn.

The new Stock Equipment Co. Model 50 Coal Scale offers:

ACCURATE, CONTINUOUS COAL WEIGHTS... WITHOUT FAIL!



with little or no attention

Day-in and day-out operation, twenty-four hours on end without interruption, is a necessity for modern central stations and industrial power plants. The demand is for equipment to handle higher tonnages with less manpower — and Stock Equipment Co. is meeting that demand with a constructive design program that keeps its entire line up-to-date.

For example: The new Model 50 Coal Scale handles higher tonnages easily with its 500# stainless steel weigh hopper, extra wide feed belt and unrestricted flow of coal 24" wide straight through the scale. Anti-friction bearings are used throughout. Even the feed belt is carried on closely spaced idlers with anti-friction bearings carefully arranged for pressure lubrication from one point on each side.

Seventeen years of designing scales exclusively for power plant use make a S-E-Co. Scale the answer to your coal weighing problem. Write for help with your particular layout of Bunker to Pulverizer or Bunker to Stoker equipment to the address below.

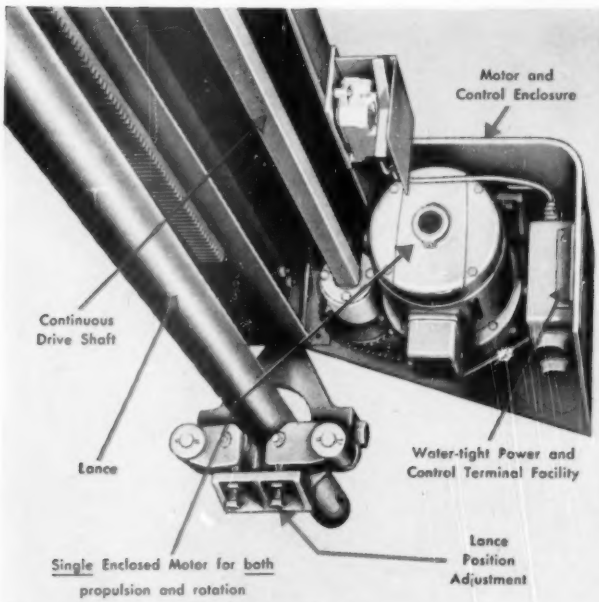
STOCK Equipment Company

745-C HANNA BLDG. CLEVELAND 15, OHIO

FRONT END Single-Motor DRIVE

another important feature of

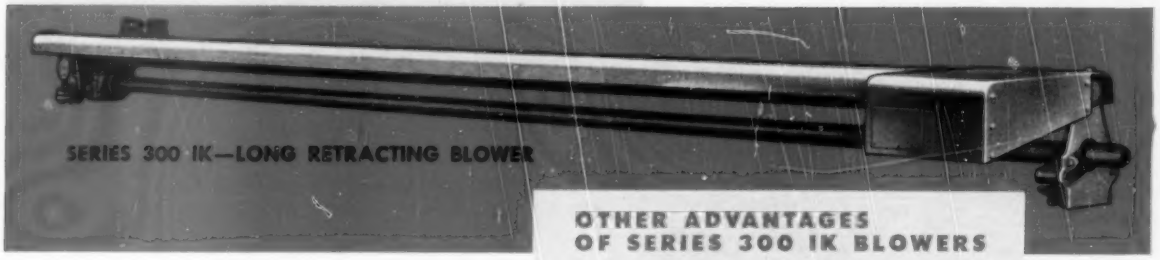
New Diamond Series 300 IK LONG RETRACTING BLOWER



Single Enclosed Motor for both propulsion and rotation
Motor mounted at boiler end for improved accessibility and better protection from physical damage and elements.
(Outboard end motor mounting optional)

As illustrated at the left, only one *motor* is used to simultaneously propel and rotate the lance tube of the new Series 300 IK. The motor is stationary and is mounted at the boiler wall for easier accessibility and greater protection from physical damage and the elements (note the protective enclosure). This front end single-motor drive is simple and dependable. There is only one set of motor elements . . . one set of control elements . . . and one set of power supply facilities to operate and maintain.

Additional important features of the new Series 300 IK are listed in the panel below. Check them and you will understand why this blower is establishing a new standard of efficiency, economy and dependability in cleaning those heating surfaces that require a long retracting blower. For further information about the new Series 300 IK, ask your local Diamond office or write directly to Lancaster for Bulletin 2111V.



OTHER ADVANTAGES OF SERIES 300 IK BLOWERS

- Backbone and Protective Cover
- Compact, Accessible Electric Power and Control Terminal Facilities
- Nozzle-Sweep-Every-Inch Cleaning Pattern
- Improved "Type A" Nozzle
- Positive Gear Carriage Drive
- Poppet Valve with Adjustable Pressure Control
- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other blower gives you all these advantages.

Diamond

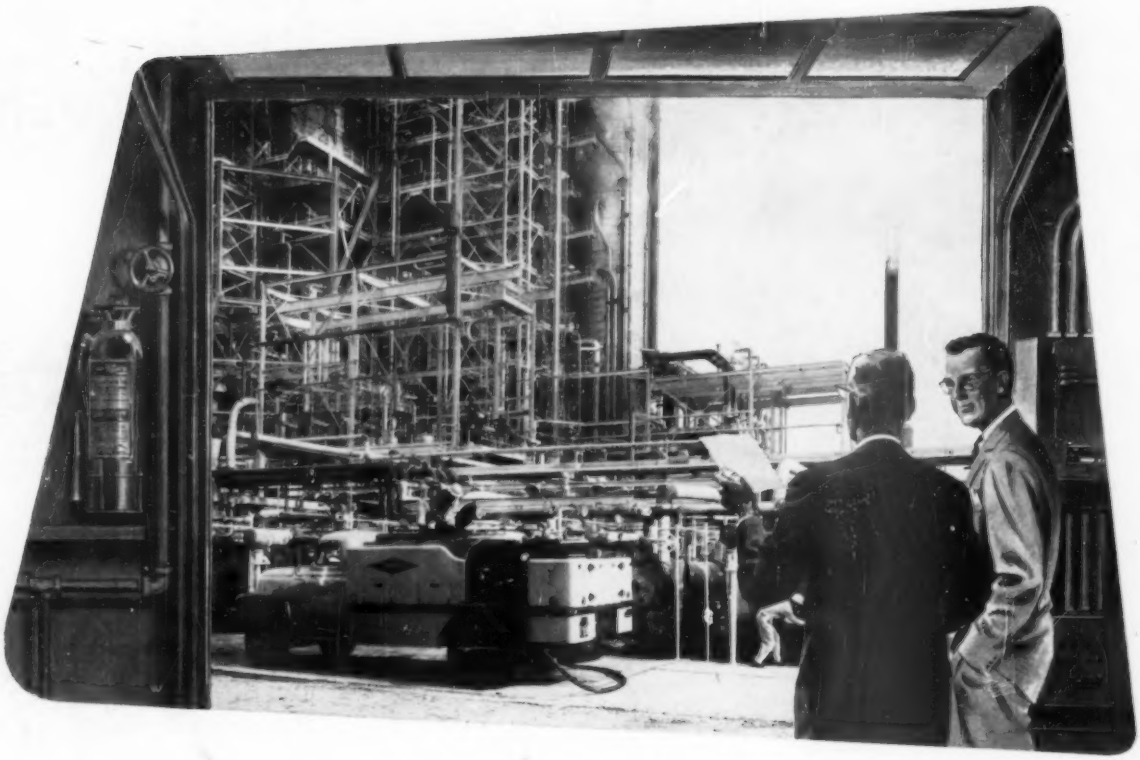
DIAMOND POWER SPECIALTY CORPORATION

LANCASTER, OHIO

Diamond Specialty Limited
Windsor, Ontario

7765

Dowell Service Helped This Plant Profit By Saving $312,700 in Maintenance Costs!



To clean and service the giant catalytic crackers in today's modern refineries is quite a job . . . and very costly. Costly, that is, unless Dowell Service is on the job to help clean the "cats"—chemically. Here's an example of how Dowell chemical cleaning service cut turnaround costs for one refiner by $312,700.

Dowell was called in to provide cat cracker turnaround service which included the cleaning of: two flue gas coolers, two catalyst coolers, four overhead aftercoolers, one light gas oil cooler, one heavy gas oil cooler, two top tray reflux coolers, and two final gas condensers.

Dowell's time: thirteen and one-half hours; Cost: $2300.

It is estimated that this same cat cracker service, if done by mechanical methods, would have cost the refinery: 1) Additional downtime of seven days—$210,000; 2) Additional spare bundle inventory—$100,000; 3) Labor—$5,000.

The refinery enjoyed a $312,700 operating credit from this single cat cracker turnaround—not including expected efficiency increases.

Dowell provides expert service in removing scale and sludge from product, process and steam generating systems. Dowell does the job for you—furnishing all chemical solvents, trained personnel, pumping and control equipment. Furthermore, Dowell has the experience in chemical cleaning to provide assurance of a job well done.

While the example here deals with an oil refinery, Dowell chemical cleaning has recorded similar profit-making savings for other industries. Dowell engineers can show you performance data in almost any field — steel, chemical, power, paper, construction.

For specific information on how Dowell chemical cleaning can help your plant to greater profits, call the Dowell office nearest you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

have Dowell clean it chemically DOWELL

A SUBSIDIARY OF THE DOW CHEMICAL COMPANY